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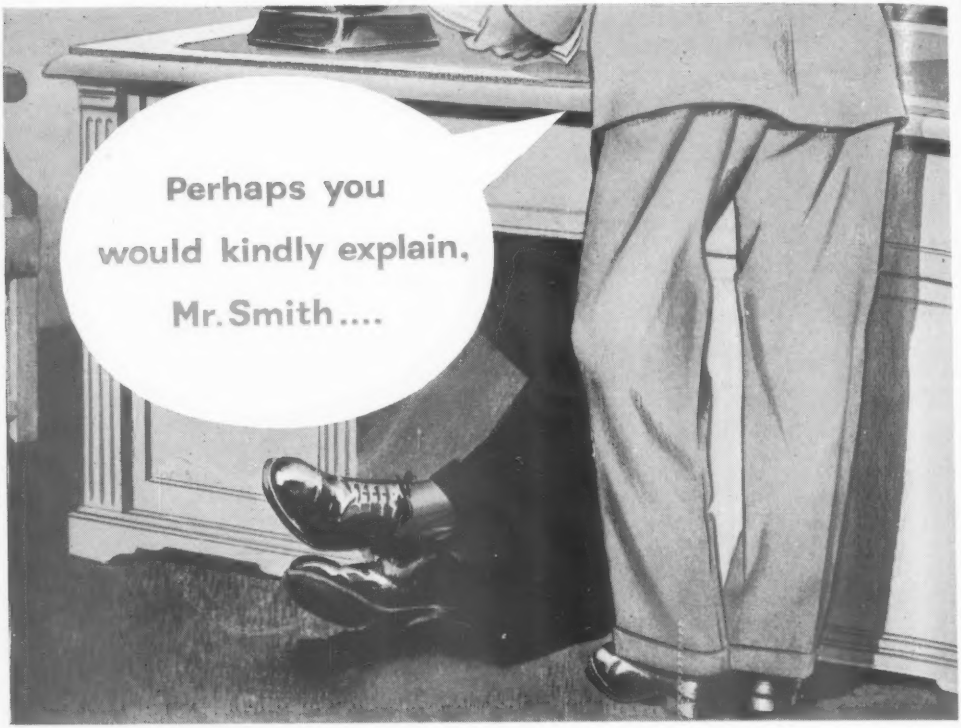


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# Sand, Coke and Noise

No fewer than 100 technical papers were presented to the 60th annual congress of the American Foundrymen's Society, and from them we have culled pointers which are of more general interest. As all founders, except die-casters, use sand, it is of interest to note from a paper by Prof. R. W. Heine, Mr. E. H. King and Mr. J. S. Schumacher, that the 14 lb./2-in. dia., ram procedure used in the American standardized system for the preparation of sand test-pieces, does not yield conditions which enable the results to be compared with those resulting from jolt/squeeze moulding; weights of 2 and 4 lb. and a 2-in. drop are recommended. A second paper by Prof. Heine, "Moulding Sands, Moulding Methods and Casting Dimensions," covers the potentialities of high-density sands and we reproduce his final remarks: "The true capabilities of green-sand moulding include the possibility of making castings of predictable, and therefore accurate, dimensions and weight. For the most part, current practices are not producing castings that measure up to the capabilities of the process. This is largely because present moulding equipment does not generate sufficient power in jolting and squeezing to produce the density and hardness of high-strength moulding sand needed for accurate castings. However, improvements in moulding machines, based on the principles presented here suggest themselves. Such machines are being built; with improved equipment, the best green-sand castings are still to be made."

While attending the recent Charleville conference, we were much impressed by the report of a visit to America by a French expert who insisted that in the States, foundrymen devote as much attention to sands as to controlling the properties of the metal. Now, in a further contribution at the AFS congress, by Mr. Meader, on "Green-sand Casting Finish," we read: "Most large and medium-size foundries, and many of the small ones, are equipped to do sand testing, but the foundrymen pay little attention to what goes on in the sand laboratory, or the results of the daily routine sand tests. The young man from the laboratory comes into the foundry at certain times during the day and picks up sand samples, maybe in nice moisture-tight containers, and takes them to the laboratory on a special cart or hand truck. There he runs the tests and records the results on nice record cards—moisture, permeability, green-strength, deformation and dry-strength. Then what happens? I will tell you, confidentially. He neatly files them away. Why? Well, the superintendent is too busy to look at them, he has more important things to do. The foreman is too busy getting out production, watching quality, including being a practising psychologist to his men, and perhaps the supervisors do not understand

(*Continued on page* 5)

**GEORGE MACBETH MENZIES**

*Chairman, British Steel Founders' Association and Managing Director, North British Steel Foundry, Limited*

*Featuring . . . .*

## GEORGE MACBETH MENZIES

GEORGE MACBETH MENZIES, the new chairman of the British Steel Founders' Association, was educated at The Edinburgh Academy and joined the North British Steel Foundry, Limited, on leaving school. The firm had been founded in 1907 by his father, Mr. George Macbeth Menzies, senior. Progress was very rapid, and in 1932 at the time of the death of Mr. Menzies, senior, the firm was employing about 400 men and producing 3,000 tons of steel castings a year. Since then, there have been many developments and to-day the employees number over 1,000, the production at Bathgate being about 6,500 tons a year, and at the associated works in Edinburgh production is about 5,500 tons, giving a total production of 12,000 tons per annum.

On the death of his father, Mr. Menzies found himself managing the firm at the early age of 21, during the difficult year of 1932, and this cut through his studies at the Heriot Watt College after only two years. During the last war, as expansion at Bathgate was difficult, a steel foundry was started in Edinburgh, now the well-known firm of Bonnington Castings, Limited, and subsequently the iron foundry of Primrose & Company, Limited, was acquired. The iron foundry was later closed down, and to-day Primrose & Company is an integral part of the expanding business in steel castings of Bonnington Castings, Limited. Mr. Menzies is a director of both these companies and the sales organization of Balbardie, Limited. In addition, he is a director of a number of investment trusts and of the West Lothian Hosiery Factory, Limited, a family business started by his maternal grandfather. He is also a member of the head-office board of the General Accident Fire and Life Assurance Corporation, Limited, and until recently was a director of the Scottish Motor Traction Company, Limited, and its subsidiary, S.M.T. Sales & Service Company, Limited.

Mr. Menzies has been associated with many of the committees of the British Steel Founders' Association. The group of firms are also members of the British Steel Castings Research Association and have long been in the forefront of developments in the steel-castings field.

When it comes to hobbies, Mr. Menzies' interests are as divergent as his business interests, ranging as they do from ski-ing and golfing to Rugby football matches which, naturally, he attends now as an enthusiastic spectator.

### Sand, Coke and Noise

(*Continued from page 1*)

what the tests mean anyway." Our comment is that the truth probably lies intermediately between the two statements.

Another important raw material, coke, has been studied by Mr. John Varga, Jnr., and Mr. H. V. Lownie, Jnr., at Battelle. Here they have discovered that the mechanical strength of coke at room temperature gives no indication of this property at the higher temperatures encountered in cupola operation. It is a matter of regret that so far no attempt has been made to correlate the results of their experiments with the performance of the coke in a cupola, but no doubt this will be attempted. Beyond stating that the nuisance arising from noise is exercising the minds of American foundry executives and that the subject will soon cross the Atlantic, we would only comment in this connection that the noise made by one's own children is seldom annoying. That from the neighbour's children is really no nuisance, if he is really friendly. So, too, if foundry concerns can make friends of their neighbours, the likelihood of complaints is negligible.

## Forty Years Ago

The July 1916 issue of the FOUNDRY TRADE JOURNAL contains a full account of the annual meeting of the British Foundrymen's Association, and Mr. J. Ellis, the incoming president, was the first to be invested with the chain of office given by the retiring president, Mr. W. Mayer. Mr. T. H. Firth was elected senior vice-president. Recently the JOURNAL received a query from an Australian reader, for help in the recording of technical literature, and indeed an article has been commissioned. Here, in 1916, is printed a quite useful contribution to the subject entitled "How to make Use of Technical Literature." There is also an article on a "Cupola with Preheated Blast," using pipes inserted in the lining of the stack, a ring main at the charging level, and other pipes leading down to the tuyeres. This issue, under "New Companies," records the registration of Bamfords, Limited, of Uttoxeter and Lichfield.

## ECSC Link with Parliament Urged

A resolution has been passed by the Common Assembly of the European Coal and Steel Community calling for the creation of an 18-member joint consultative committee to link the community with the Parliament of the United Kingdom.

The president of the community's High Authority, M. René Mayer, has promised to ask for the inclusion of the resolution in the agenda of the next meeting of the Council of Association with Great Britain which is to be held in Luxembourg on July 10.

THE ADDRESS of the Institute of Metals has been changed to 17, Belgrave Square, London, S.W.1 (Telephone: BELgravia 3291). The joint library and information department of the Institute, however, remains at 4, Grosvenor Gardens, London, S.W.1.

## Australian Foundry Statistics

In the "Survey of Manufacturing Activity in Australia," briefly reviewed in the JOURNAL, June 28, considerable space is devoted to the foundry industry. It is recorded that, although since 1955 Australia has produced about 9,500 tons of virgin aluminium annually, because of high labour costs and the high price of aluminium in the Australian market, United Kingdom competition for die-castings cannot be met. There are about 500 non-ferrous sand foundries, employing some 5,500 persons, in the country, but since December last there has been a noticeable decline in production, except in Victoria and South Australia, where conditions are static. About 40 steel foundries are located in the Commonwealth, employing over 4,000 men. Production in this section has tended to decline in recent times, but the market for alloyed steel castings is strong. In the section of the Report entitled "Baths, Stoves, and Sinks," it is stated that in 1955, Australia produced 112,000 cast-iron porcelain-enamelled baths, whilst the output of solid-fuel, gas, and electric stoves was of the order of 156,000.

## ISHRA Accounts

Accounts of the Iron and Steel Holding and Realization Agency for 1954-55, published as a White Paper, show that the agency paid into the realization account sums totalling £91,630,552 and withdrew £45,100,000. The amount paid in comprised receipts from the sale of iron and steel undertakings, but did not include the value of Government securities coming into the hands of the agency. The agency's accounts for the period ended September 30, 1954, showed a net revenue surplus of £2,956,212. The balance in the Iron and Steel Realization Account rose from £18,135,671 on April 1, 1954, to £61,710,011 on March 31, 1955.

During the year £30,300,00 was issued from the account to the agency to allow it to repay outstanding loans from bankers of that amount which they took over from the Iron and Steel Corporation. Since the close of the year, £25,000,000 has been transferred from the account to the Exchequer.

### Plimsoll-line Restriction!

It is regretted that not all the applications to attend the IBF London branch works visit to Lafarge Aluminous Cement Company, Limited, on July 17, can be accepted, owing to the limit of accommodation on the Thames launch which has been chartered for the trip. The company has relucantly restricted acceptances to the first 60 applying, as it has proved impossible to hire a larger boat. It will be appreciated if any member of the party who at the last minute finds himself unable to make the trip will advise the London branch secretary, so that the place may be offered to the next in order on the list of those so far disappointed.

### Dr. J. E. Hurst honoured

At a ceremony held recently at the Karlsruhe Technical University, Germany, Dr. J. E. Hurst, C.B.E., D.MET., J.P., a past-president of the Institute of British Foundrymen, was invested with the degree of Doctor of Engineering, *honoris causa*.

THE Federation of Light Metal Smelters announces that its members' average selling prices for May, to the nearest 10s., have been calculated as follow:—LM1, £196 per ton; LM2, £192 10s.; LM4, £205 10s.; LM6, £213.

# Scrap Investigation

By J. McGrandle

MR. MCGRANDLE is chief metallurgist with Mavor & Coulson, Limited, Glasgow, mining-machinery manufacturers. He commenced his apprenticeship as a moulder in the firm's foundry, spent two years at the Birmingham laboratories of the British Cast Iron Research Association under a student training scheme, and subsequently returned to his present company. He is an associate of the Institution of Metallurgists, and as a member of the Institute of British Foundrymen holds the John Surtees' silver and gold medal and a diploma of the Institute. His technical education was obtained at Central Technical College, Birmingham, and Royal Technical College, Glasgow.

*Papers given to the Institute of British Foundrymen are usually in one of two categories, technical or practical. The Author, with some dubiety, in this Paper avoids the purely technical and practical as much as possible. This may sound almost like heresy, but occasionally if one stands back from a problem and avoids details, a better overall view, and occasionally a new slant on the problem are obtained. This is particularly the case when attempting an investigation on foundry scrap, dominated by seemingly endless causes and effects and a multitude of variables. Detailed descriptions of particular faults occurring in castings will therefore be avoided, unless necessary to classify or amplify the main theme. Numerous papers and the Institute's "* Atlas of Castings Defects *" cover very ably this subject of fault identification and cure. Since the Author is associated more with cast iron than other cast metals, and thinks in terms of this material, some remarks, particularly regarding metal quality, will not necessarily apply to other metals. Most foundries make some scrap—"most" is used deliberately—since there may be founders who refute the statement if applied to "all." No two foundries are identical; the differences which exist in their products, labour, plant and other facilities are such that comparisons of scrap returns between different foundries would be not only unfair, but much more important, actually misleading.*

## Introduction

It is possible for one foundry to make a higher proportion of scrap than another and similar class of foundry and yet be more efficient and economic. What is really more rewarding is a comparison between the actual scrap a foundry produces and the potential reduction possible when variables are examined, assessed in importance and controlled—where feasible—to narrower limits. The cost of altering or controlling these variable factors more accurately can then be estimated against the value of the scrap reduction envisaged on a financial basis.

In fairness to all sides, this discussion on hypothetical scrap percentage or numbers is neither a reflection of figures from the foundry with which the Author is associated, nor for that matter a reflection of any figures which may occur in foundries with which readers may be associated. The figures relating to scrap are quoted purely for the purpose of illustration and bear no relationship to actual practice. However, when ratios of different types of scrap, and importance of factors are concerned, the illustrations will not be so divorced from reality.

There seems to be a rough scrap percentage bandied about between foundrymen of five or six per cent. For general foundry practice, this figure is either governed by some law of compensation of variable factors, or more likely due to a natural tendency to be not too different from others. A foundryman does not like to admit to a much higher figure, and if he quotes a percentage materially lower he is afraid his associates will accuse him of boasting or falsifying his returns. There is also a dangerous and prevalent attitude of accepting some percentage of scrap as normal. That there will be some scrap is assumed, although at one time the Author enjoyed the argument that theoretically it was possible to produce 100 per cent. good castings. A foundry may have 3 per cent. scrap returns; then, if the scrap rises to 5 per cent. there is subconsciously a view that the scrap is 2 per cent., in other words, the 3 per cent. is assumed to be unavoidable. If, for any reason, the scrap falls significantly below the normal figure, everyone wants to know why. There may be many justifiable reasons why the normal scrap allowance is accepted —economic, labour, quality, and the seemingly hopeless task of arriving at some conclusion from a mass of unrelated causes and effects.

## Divergent Approaches

In an approach to scrap investigation, different circumstances require different treatment. If foundries are divided roughly into three types and the scrap situation into two categories, it can be seen that the problems and therefore the methods of approach are different, *viz.*:—

(1) Foundries making a few very large and expensive castings, where one scrap casting represents a minor disaster.

(2) Foundries where only a few types of

*Scrap Investigation*

castings, usually very similar, are made in large quantities, *i.e.*, mass production.

(3) General foundry production, where any number from one to 1,000 off are required from a wide variety of patterns.

In the first type of foundry, every possible precaution is taken to make sure each casting is a good one, and variables are controlled mainly by close supervision of all operations. An excellent paper on this aspect "System of Studying Casting Rejects" by Nicholls & Kershaw was given to the IBF conference in 1951. In mass-production foundries, speed of output is a first essential; many controls, fixed due to and because of mechanization, and the high quality of pattern and other equipment necessary for high-speed production, reduce the number of variables considerably. Quality control as a technique is usually practised in this type of foundry and "quality control is achieved most efficiently, of course, not by the inspection operation itself but by getting at causes" (Dodge and Romney). In the third type of foundry, that most frequently encountered, variables are at a maximum and often controls are at a minimum. This is the problem the Author wishes mainly to deal with, although certain aspects are applicable to mass-production foundries.

Two situations as regards scrap may exist in any foundry, often side by side, and they may or may not bear a direct relationship to one another. These two situations are the acute and the chronic. For the acute state, as implied by the word acute, something must be done immediately and usually all the technical resources and experience of the staff, with or without outside assistance, is focused on the problem. Several precautions are taken and, if necessary, alterations to casting design are made. Some sort of a cure is found, but what alterations resulted in the cure is not always certain and when a similar situation again arises, the same steps may not solve the problem.

Not so with the chronic situation, then the fault in each casting may be insufficient to cause it to be scrapped, although the casting is not all it might be. Alternatively the percentage scrap may be low enough to stop action being taken. More usually, "chronic" scrap is scrap from different kinds of faults and causes in different types of castings, annoying, obscure and not easy to come to grips with. This type of scrap tends to be treated as an annoyance, the foundryman's burden, and is quietly absorbed in the normal scrap allowance, instead of being systematically dealt with and its causes removed. This type of scrap sometimes leads to an epidemic increase of general scrap, but this question of epidemics will be left till later.

## Collection of Data

One of the problems in the normal type of foundry, is the method of collection of data from a systematic examination of scrap castings, and sorting or re-arranging this data in some manner which should present a pattern of behaviour of cause and effect. Many foundries do collect such data and some make full use of this information, but how many foundries collect records on scrap returns, have them piled high in confusion and any attempt to find out what they mean, other than in lost money, is hopeless? Again, how many foundries could one go into where the only idea of scrap is gross weight or a graph like a violent switchback?

One can get no more information, and usually less, out of a survey than is represented by the total information collected, and the value of any final analysis is to a great extent dependent on the

TABLE I.—*Statistical Method of Correlating Cause and Effect of Foundry Scrap*
RANDOM NUMBERS.

| | Dirt. | Slag. | Drawn. | Scab. | Erosion. | Cold shut. | Large blowhole. | Small blowhole. | Totals. |
|---|---|---|---|---|---|---|---|---|---|
| Venting | 03 | 47 | 43 | 73 | 86 | 36 | 96 | 47 | 431 |
| Gating | 97 | 74 | 24 | 67 | 62 | 42 | 81 | 14 | 461 |
| Hard or friable cores | 16 | 76 | 62 | 27 | 66 | 56 | 50 | 26 | 379 |
| Poor casting practice | 12 | 56 | 85 | 99 | 26 | 96 | 96 | 68 | 538 |
| Bad ramming | 55 | 59 | 56 | 35 | 64 | 38 | 54 | 82 | 443 |
| "Dull" metal | 16 | 22 | 77 | 94 | 39 | 49 | 54 | 43 | 394 |
| Careless moulding | 84 | 42 | 17 | 53 | 31 | 47 | 24 | 55 | 353 |
| Damp sand | 63 | 01 | 63 | 78 | 59 | 16 | 95 | 54 | 429 |
| Weak sand | 35 | 21 | 12 | 34 | 29 | 78 | 64 | 56 | 329 |
| Patterns | 57 | 60 | 86 | 32 | 44 | 09 | 47 | 27 | 362 |
| Boxes | 18 | 18 | 07 | 92 | 46 | 44 | 17 | 16 | 258 |
| Drying | 26 | 62 | 38 | 97 | 75 | 84 | 16 | 07 | 405 |
| Metal | 23 | 42 | 40 | 64 | 74 | 82 | 97 | 77 | 499 |
| Design | 52 | 36 | 28 | 10 | 95 | 50 | 92 | 26 | 398 |
| TOTALS | 557 | 616 | 638 | 864 | 796 | 727 | 883 | 598 | 5,679 |

accuracy and value of the original data. This may sound too axiomatic, but how often do founders try to interpret from unreliable data?

Two aspects in the collection of data are of primary importance (*a*) correctly naming the fault which causes a casting to be rejected, (*b*) correct diagnosis, *i.e.*, identifying the cause of a fault correctly. This is no task for an unskilled or untrained man, nor for a foreman if the data is to be reliable. It is a difficult job and only the co-operative effort of management, laboratory and works staff, and foremen, can find a correct answer to these questions. To ignore borderline items, as will be shown later, is a grave mistake, and to omit castings which may be salvaged by welding or burning, is yet more grave. Bias, due to preconceived ideas, or tendency to attribute the causes or faults to unknown or uncontrollable factors, must be rigorously excluded. This always leads to "passing the buck."

## Card System Proposed

Daily examination of all scrap from the foundry and a weekly examination of scrap from the machine-shops should be carried out, recording the number of castings made, number and percentage of scrap in each job, the type of faults and the causes of these faults should be determined and recorded; the moulder's name and/or number must also be noted. The amount of information so obtained is complex and often the variables involved are so numerous as to discourage the most ardent in attempting to get any real information therefrom. This information may then be entered on cards, examples of which are shown in Fig. 1 (*a*) and (*b*). Any firm which has a punch-card machine, such as a Power Samas, or a Hollerith, will appreciate its value for the purpose of analysing this information. These cards, as shown, cannot attempt to collect and correlate so many facts as can power-operated punch-card machines. However, perhaps the cards illustrated in Fig. 1 (*a*) and (*b*) are really more suitable since one is prevented from collecting too much information, half of which may be irrelevant. The information is filled in on the cards, and the appropriate holes punched out; each type of casting is filed under its own drawing number. One card may conveniently be used for several faults, provided the faults are not more than about three or four, otherwise an additional card is necessary. If different operators are engaged in making the same casting then a separate card is required for each man.

For statistical analysis, the information on a card should be as simple yet as precise as possible, and subtle shades of meaning are to be avoided. At the end of a specific period, the cards may easily be manipulated to select information on a number of inter-related facts. For instance, one may separate all cards showing dirt in the casting by manipulating the cards as shown in Fig. 2 and then, under cause of fault, further separate the cards punched for "dirt," under their respective headings.

The total number or weight of castings due to dirt against total castings or percentages can easily be obtained by adding up the accumulated totals for each card in that category. The further subdivision of causes of faults is done likewise. The same procedure is carried out for all other faults, and the totals may then be listed as shown in Table I.

In this table the figures correlating cause and effect are shown. The figures represent purely random numbers taken from a special table of random numbers, 1-100. The figure may be a number or weight of scrap in pounds or cwts. If such a result were obtained in practice—which is, however, unlikely—then the variables listed are such that none predominates, *i.e.*, each has the same

TABLE II.—*Example of the Type of Information where Attention to a Selected Small Number of Factors can give the Best Overall Results.*

| | Dirt. | Slag. | Drawn. | Scab. | Erosion | Cold shut. | Large blow-hole. | Small blow-hole. | Crush. | Swell. | Cracked | Dimen-sions. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Venting | — | — | — | — | — | 11 | 20 | 8 | — | — | — | — | 39 |
| Gating | 10 | 8 | 40 | 8 | 12 | 32 | 18 | 15 | — | — | 4 | — | 147 |
| Hard or friable cores | 6 | — | — | — | 21 | — | — | 6 | — | — | 9 | — | 42 |
| Poor casting practice | 8 | 23 | — | — | — | 10 | — | — | — | — | — | — | 41 |
| Bad ramming | — | — | — | 40 | 5 | — | 10 | — | 9 | 17 | — | 6 | 87 |
| "Dull" metal | 4 | — | 21 | — | — | 40 | — | 31 | — | — | — | — | 96 |
| Careless moulding | 23 | — | — | 18 | — | — | — | 8 | 11 | — | — | 19 | 79 |
| Damp sand | — | — | — | 12 | — | — | 14 | 21 | — | 15 | — | — | 62 |
| Weak sand | 6 | — | — | 8 | 13 | — | — | — | 4 | — | — | — | 31 |
| Patterns | — | — | — | — | — | — | — | — | — | — | — | 8 | 8 |
| Boxes | — | — | — | — | — | — | — | — | 25 | — | — | 18 | 43 |
| Mould drying | — | — | — | 23 | — | — | 4 | — | — | — | — | — | 27 |
| Metal | — | — | 14 | — | 9 | — | — | — | — | — | 13 | — | 36 |
| Design | — | — | 30 | — | — | 8 | — | — | — | — | 23 | — | 61 |
| TOTAL | 57 | 31 | 105 | 109 | 60 | 101 | 66 | 89 | 49 | 32 | 49 | 51 | 797 |

*Scrap Investigation*

importance. The method of reducing scrap in this case would be surely to slightly improve all these variables.

If even one variable were altered significantly then the figures would change and show some bias, although it might take a first-rate statistician a long while to make the figures mean very much. However, in practice one can be assured that complete or even near randomness of these numbers does not occur, *i.e.*, bias will be shown. (*Note:* The sum of the totals do not all come out as exactly as one would expect; there is a mathematical relationship between the total number of random sample numbers and their accuracy, so that in practice, with real numbers or facts, undue stress must not be placed on small variations.)

In reality, something like the results shown in Table II will occur. Here it can be seen that it would be a waste of time to deal immediately with weak sand or drying of moulds, but poor gating, "dull" metal, and the elimination of small blowholes, are the major items requiring attention. This table may be over-simplified to bring out the principle of assessing the factors involved. If the last column is listed for each succeeding period, a picture of improvement in any cause may easily be obtained.

**The Human Element**

Further to clarify the human factor, one can easily list faults or causes—whichever be preferred (or both), against the moulder. The Author prefers to use the moulder's name rather than his check number, since the results have more meaning, unless, of course, the men are only known by their check numbers! Some interesting facts may come to light, and Table III shows some idea of what may occur. What can be done about it? Obviously Mr. Smith is more liable to have castings with misruns and cold-shuts than any other moulder (bearing in mind, of course, the style of work Mr. Smith is doing, otherwise false conclusions may be reached); Brown has more scabs on top parts, and so on.

Either an attempt can be made to educate these men to overcome their weak points or no jobs should be given to specific moulders which are liable to the types of faults which he is prone to produce. It may be said that any foundry manager or foreman should, or does, know the weakness of his men. Such may be the case in small foundries, but in larger foundries with all the attendant duties of staff and managers, close contact with this problem of the men's human failings, their individual methods, strengths and weaknesses, is not always possible. Many of the opinions as to men's abilities are *only* opinions and rather vague and perhaps not always justified. The allocation of jobs may not always be in the hands of personnel competent to judge in this respect. As a guide, a list could be made of jobs or types of jobs which may or may not be given to certain moulders.

**Types of Castings**

Further analysis under types of castings will inevitably indicate faults common to all types, or faults common to specific types of castings. These faults may then be investigated and perhaps it will be found some property in the sand suits one type and not another type of casting. This would suggest a compromise in sand qualities or a change to two types. Gating may be weak in one type. In this respect, one should seek to find common factors and important single factors requiring some alteration.

To see what effect alteration to specific factors or any factor should have on the scrap, a particular casting can be selected and 100 made, using normal foundry practice but seeing that no abnormal occurrence takes place. Assuming that 95 per cent. of the castings are good and 5 per cent. scrap, on further examination it may be found that of the 95 per cent. good castings perhaps 10 per cent. just pass, 60 per cent. have minor faults and 25 per cent. are to all intents and purposes perfect. Then one should not generally expect more than 5 per cent. scrap on any further batch.

Next, let it be assumed that another 100 castings are made in another circumstance, and on examining them 5 per cent. scrap is found, 50 per cent. just passing, 40 per cent. have minor faults and 5 per cent. are perfect. The probability of 5 per cent. scrap in the next 100 to be made is less

TABLE III.—*Example where Salient Features Indicate the Need for Discriminatory Action.*

| Moulder. | Defect. | | | | | | | | Cause of defect. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dirt. | Slag. | Cold shut. | Draw. | Scab. | Swell. | Small blow-hole. | Large blow-hole. | Gating. | Ram-ming. | Care-less-ness. | Venting | Total. |
| A. Smith .. .. .. .. | 4 | 8 | 21 | 0 | 2 | 1 | 25 | 0 | 30 | 9 | 12 | 0 | 51 |
| Jones .. .. .. .. | 23 | 16 | 5 | 6 | 11 | 0 | 5 | 9 | 10 | 8 | 35 | 7 | 60 |
| Brown .. .. .. .. | 2 | 3 | 16 | 0 | 0 | 2 | 14 | 0 | 8 | 2 | 0 | 0 | 10 |
| McDonald .. .. .. | 0 | 1 | 4 | 7 | 1 | 1 | 0 | 0 | 3 | 1 | 0 | 0 | 4 |
| D. Smith .. .. .. .. | 14 | 11 | 0 | 18 | 0 | 0 | 4 | 8 | 5 | 0 | 14 | 8 | 27 |
| Black .. .. .. .. | 11 | 9 | 2 | 1 | 0 | 0 | 23 | 2 | 5 | 6 | 5 | 1 | 17 |
| White .. .. .. .. | 1 | 4 | 5 | 0 | 8 | 1 | 0 | 1 | 1 | 2 | 0 | 0 | 3 |
| TOTALS .. .. .. | | | | | | | | | 62 | 28 | 66 | 16 | |

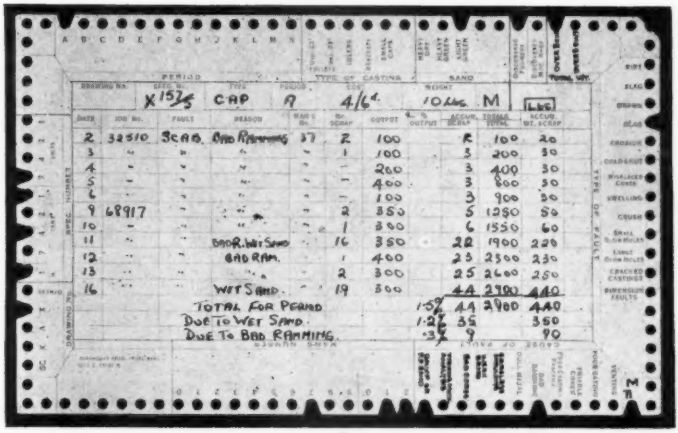



FIG. 1 (*a*).—*Method of collecting and arranging data in a punched-card system.*

certain, since there is a probability of more drifting in from the 50 per cent. just passing than from the 5 per cent. scrap into the "just passing" category; a slight movement of any one variable in an adverse direction in the second instance may increase the scrap enormously.

### Epidemics

This is, it is suggested, a particular cause of epidemics of bad castings, difficult to pin down to any special reason. Of course, an epidemic may be caused by one major factor, *e.g.* sand or metal being completely out of control, but this type of trouble is more easily defined and comes more aptly under the heading of the acute scrap-situation. An epidemic, due to a slight shift in one or two variables, however, is much more difficult to solve. Nevertheless, a warning may have been given in the slow increase of "near scrap," before the actual scrap showed a signficant increase.

This brings out a point in the examination and collection of data regarding scrap. For the purposes of such an investigation, castings reclaimed by welding or other methods should still be classed as scrap, and "near scrap" dealt with likewise. At the very least they should not be ignored.

### Inspection

The sudden scrap epidemic mentioned previously may be due to an alteration in inspection, and the larger the number of "just passes" at an earlier stage, the greater the increase in scrap consequent upon tighter inspection. Here again, the problem becomes acute and requires corresponding treatment.

A diagram can be made of the defects in castings and their possible causes, an example being shown in Fig. 3 (by courtesy of Mr. Summer, of the British Cast Iron Research Association). The number of potential variables and their effects are excellently depicted, but it is not intended to dwell on the technical side of these matters. If one could remove all the variables due to metal faults, how much more simple would the diagram be ?

### Elimination of Variables

If one could completely standardize and fix the gating and riser system, plus moisture, green-strength and permeability of sand, the diagram would look somewhat like Fig. 4 (with apologies to Mr. Summer). Again, if the variation in sand could be reduced to limits which prevented such expressions as "too damp" or "permeability low", not only would there be less scrap castings but the job of diagnosing the real reason for a scrap casting would be simplified.

When preparing this Paper, the Author was pleased to note the "leader" in the FOUNDRY TRADE JOURNAL for January 12, 1956, brought up the question of the control of variables. This leader was inspired by an article in the American magazine *Grey Iron News* for December 1955, and copy was obtained on loan. In this article 69 variables are listed, 47 of which could directly affect the quality of the casting. The list is under three headings—"the variable"; the effect of "too large" or "too much"; and the effect of "too

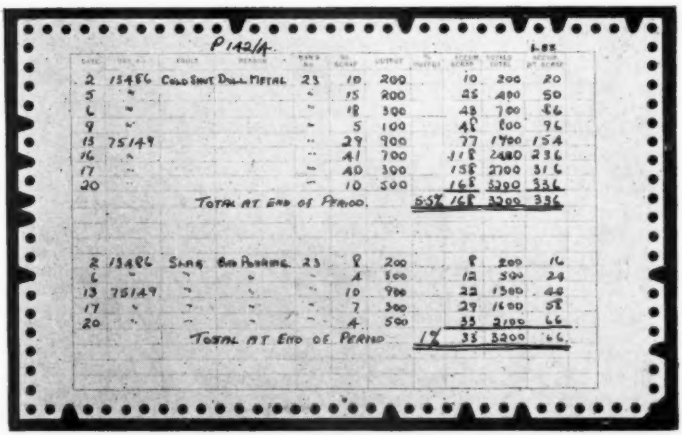



FIG. 1 (*b*).—*Further example of collecting and arranging data in a punched-card system.*

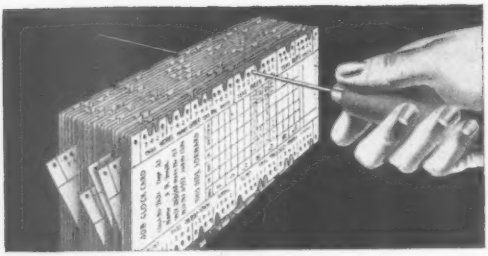


FIG. 2.—*Method of manipulating punched cards for the selection of information.*

little" or "too small". If one examines these variables, the possibilities of controlling many to narrower limits by better control is obvious. Any foundryman making such a list out for himself will, the Author believes, get a fresh picture of some of his problems and perhaps possible solutions.

Fig. 5 may be called "the foundrymen's nightmare" but it does no harm to show the complication present in making a casting. If engineers look at such a diagram, while they may not excuse a foundry for supplying castings which subsequently have to be scrapped during machining, perhaps they may appreciate some of the founders' difficulties.

The unfortunate thing about diagnosing the cause of scrap castings is that when one gets the casting into the dressing shop, so much of the evidence has been permanently destroyed. The moment the mould is poured, evidence as to moisture content, dirt in the mould, degree of ramming, casting temperature, etc., are lost for ever. When the casting has been half dressed and gates and risers knocked off, further evidence is destroyed. Therefore, the greater the number of factors known to be within the fixed limits of control the easier it is to state the real reasons for the scrap.

### Probability of a Scrap Casting

Next, it is intended to illustrate what may happen if one applies some of the concepts of probability to this question of scrap castings. First, in a general way, the probabilities and variables will be dealt with and then an attempt will be made to apply this to the scrap problem. The use of the words "probabilities" and "variables," would perhaps be better understood if clarified. "Probabilities" are expressed in terms of numbers. P=0 expresses the fact that an event can never take place and P=1 that an event is a certainty. As is well known, certainties are few, and most events have some degree of uncertainly. The degree of probability is then expressed thus—P=0.5 is a 50-50 chance; P=0.2 is a four-to-one-against chance. A variable is some factor which is not constant.

### Crown and Anchor

The reader may be conversant with the game of "Crown and Anchor" but the Author confesses to never having played the game. Three dice are used, each having on the six separate faces a crown, an anchor, spade, club, diamond, and heart. If these dice are thrown often enough and it is recorded each time a treble, double, or single is obtained, by the laws of chance or probability the ratios will be: trebles, six or 2.77 per cent.; doubles, 90 or 41.7 per cent.; and singles, 120 or 55.5 per cent. If, say, the crowns in all three dice are blanked off, *i.e.* the crown no longer comes into the game except as singles, and the result is as follows: trebles, five or 2.3 per cent.; doubles, 75 or 34.7 per cent.; and singles, 136 or 63.0 per cent.

Assuming the six faces, *i.e.* clubs, diamonds, etc., represent factors out of control in a foundry to such a degree as to be just sufficiently potent to produce scrap if they coincided with a similar adverse factor, then the percentage scrap would be 44. If one of the variables was fixed so as to have no effect, the scrap would be 37 per cent. Next, if the potency of these six variables could be reduced to such a limit that it required three adverse factors to produce a bad casting, then the scrap would go down to less than 3 per cent. Thus, in this instance, it would pay better to tighten up on controls all round than to concentrate on removing one of them. However, the position is not quite as simple as this, since most variables fluctuate between more-or-less-defined limits—limits, it is suggested, which are in some cases wider than they need be.

### Confining the Limits

If any variable over a period is plotted graphically, the variations obtained in practice look like a saw with uneven teeth. Horizontal lines can be drawn to represent some safe limits where the exercise of this factor has no adverse effect on the casting. Then, the number of times the readings are out with the limits, compared with the number of times readings are taken, gives the probability—at any particular instant or in any particular mould or casting—of the factor being adverse.

$$p = \frac{\text{Number of readings outside the limits}}{\text{Total number of readings.}}$$

Let there be $n$ variables and it be assumed that the probability, $p$, of each variable is outside the limit (*i.e.* adverse) to be equal in all these variable factors:

If $p_1$ = probability of first variable being adverse, $p_2$ = probability of second variable being adverse, and $p_3$ = probability of third variable being adverse, and so on, $n$ being the number of variables.

The following formula shows the probability of one, two, three, or more variables, in this case adverse variables, coinciding in one event or casting—

$$P = n \times p + \frac{n(n-1)}{2} p_1 \times p_2 + \frac{n(n-1)(n-2)}{2 \times 3} \times p_1 \times p_2 \times p_3;$$

P is total probability of all factors, *i.e.*, $\sum_{1}^{n} p$.

The first expression, $np$, denotes the probability of any one adverse factor being present; the second expression $\frac{n(n-1)}{2} p_1 \times p_2$ the probability of two

adverse factors being present, and the third expression $\frac{n(n-1)(n-2)}{2\times 3} p_1 \times p_2 \times p_3$, of three adverse factors being present.

To interpret this, if $n$, the number of variables, $= 20$; $p$ = probability of each factor being adverse $= 0{\cdot}02$, *i.e.* a probability of 2, then the probability of scrap if each variable were sufficient to cause a bad casting would be :—

$$P = n \times p = 20 \times 0{\cdot}02 = 0{\cdot}4 = 40 \text{ per cent. scrap.}$$

### Potency

If the potency of each variable be reduced so that it requires two adverse variables to produce a scrap casting, then the scrap would be 7.6 per cent. If the potency be further reduced, so that it requires three adverse variable present to produce a scrap casting, then the scrap would be 0.9 per cent.

Another way of illustrating this probability picture would be to imagine 20 table-tennis balls dancing up and down in an upward current of air or water, as seen in shooting galleries. Every so often, each ball will be caught up in the upward current and rise to some random height. If an imaginary horizontal line be drawn some distance below the maximum height attained by the ball, each ball will be below this line most of the time. If this line is so arranged so that 0.01 or 1.0 per cent. of the time one particular ball is above the line, the probability of that ball being above the line is 0.01. With 20 balls, the probability of any ball being above the line is $np = 20 \times 0.01 = 0.2$ or 20 per cent. The probability of two or three balls being above the line simultaneously is given by the formula previously stated. Numerous horizontal lines could be pictured expressing numerous probabilities with red balls indicating maximum potency, green balls for potency where two adverse factors are necessary, and similarly with the white requiring three balls above the line to represent the production of a bad casting.

Starting again with different figures, if the probability of P be reduced, *i.e.*, the factors are so controlled that a lesser number of fluctuations beyond determined limits took place, say to 0.01—1 per cent. of the time each variable is adverse, there is obtained :—

One adverse variable sufficient to produce scrap—scrap = 20 per cent.

Two adverse variables are required to produce scrap—scrap = 1.9 per cent.

Three adverse variables are required to produce scrap—scrap = 0.1 per cent.

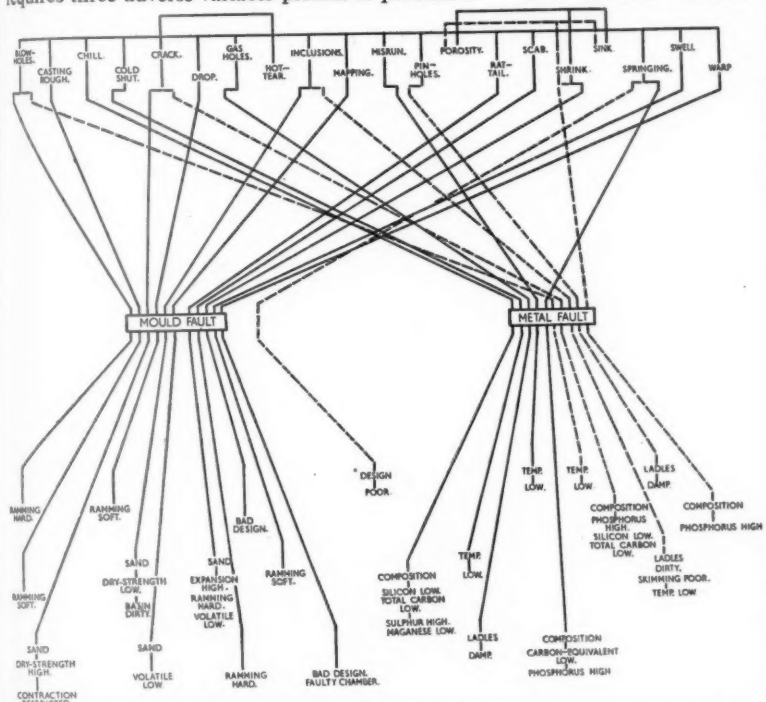



FIG. 3.—*Diagram showing the defects in light-iron castings and their possible causes channelled into metal or mould faults.*

If the same calculation is repeated for some other number of variables, that is to say, perhaps four variables are removed by strict control so that they never become an adverse factor, the result shown in Table IV is obtained.

Under such a set of circumstances, the import-

TABLE IV.—*Percentage Scrap Expected as a Result of Eliminating Certain Variables.*

| Number of variables. | $P = 20$. | | $n = 16$. | |
|---|---|---|---|---|
| | $P = 0.02$ | $P = 0.01$ | $P = 0.02$ | $P = 0.01$ |
| Potency: One variable sufficient .. .. | 40 | 20 | 32 | 16 |
| Two variables necessary .. .. | 7.6 | 1.9 | 4.8 | 1.2 |
| Three variables necessary .. | 0.9 | 0.1 | 0.44 | 0.05 |

*Scrap Investigation*

ance of controlling variables within closer limits should be clear. Of course, all realize this from experience, but it does no harm occasionally to get out of the habit of thinking of concrete examples and see what the figures themselves can indicate.

From the information given in this table—and here reference is made to the general, chronic scrap, highly undefinable—it is significant that if one improves slightly or controls slightly better all the variables, the drop in scrap is much greater than if one fixes or removes a few variables. Of course, if a variable had a probability of 0.6, *i.e.*, 60 per cent. of the time it was adverse, an effort must be made to reduce this probability, but reducing the potency of variables generally may be much more rewarding. If one variable, when slightly adverse, independently can produce bad castings, its probability must be reduced to as near zero as possible.

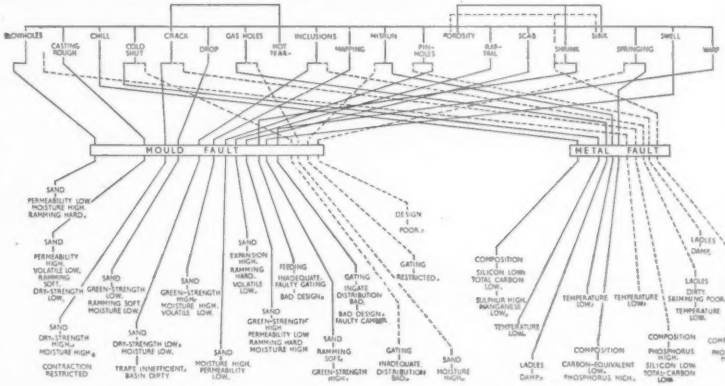

MOULD FAULT
METAL FAULT
SAND PERMEABILITY LOW, MOISTURE HIGH, RAMMING HARD.
SAND PERMEABILITY HIGH, VOLATILE LOW, RAMMING SOFT, DRY-STRENGTH LOW.
SAND DRY-STRENGTH HIGH, MOISTURE HIGH.
CONTRACTION RESTRICTED
SAND GREEN-STRENGTH LOW, RAMMING SOFT, MOISTURE LOW.
SAND DRY-STRENGTH LOW, MOISTURE LOW.
TRAPS INNEFFICIENT, BASIN DIRTY
SAND GREEN-STRENGTH HIGH, MOISTURE HIGH, VOLATILE LOW.
SAND MOISTURE HIGH, PERMEABILITY LOW.
SAND EXPANSION HIGH, RAMMING HARD, VOLATILE LOW.
FEEDING INADEQUATE, FAULTY GATING
BAD DESIGN.
SAND GREEN-STRENGTH HIGH, PERMEABILITY LOW RAMMING HARD, MOISTURE HIGH
GATING INADEQUATE DISTRIBUTION BAD.
BAD DESIGN, FAULTY CAMBER.
SAND RAMMING SOFT, GREEN-STRENGTH HIGH.
GATING INADEQUATE DISTRIBUTION BAD.
SAND MOISTURE HIGH.
DESIGN POOR.
GATING RESTRICTED.
COMPOSITION SILICON LOW, TOTAL CARBON LOW.
SULPHUR HIGH, MANGANESE LOW, TEMPERATURE LOW.
LADLES DAMP.
TEMPERATURE LOW.
TEMPERATURE LOW.
LADLES DIRTY, SKIMMING POOR.
TEMPERATURE LOW.
COMPOSITION CARBON-EQUIVALENT LOW, PHOSPHORUS HIGH.
COMPOSITION PHOSPHORUS HIGH, SILICON LOW, TOTAL-CARBON LOW.
COMPOSITION PHOSPHORUS HIGH.

FIG. 4.—*Variation of the chart shown in Fig.* 3 *to take into account the gating and risering system plus moisture, green-strength and permeability of moulding sand.*

## Practical Aspects

Attempts can be made to reduce the variables in number, reduce their "potency," or reduce the probability of each factor occurring. Simply reducing the number of variables may not, the previous table being consulted, reduce the scrap very much, but it does simplify considerably the investigation into causes of scrap castings.

There are several classes of variables which can be dealt with:—

(*a*) *Imagined or Exaggerated Variables.*

The following two variables have been dealt with recently in foundry literature (*vide* "Fluidity of Molten Cast Iron," by Evans, and the Report of the Joint Committee of the Institute of British Foundrymen and the BCIRA on "Gases in Cast Iron"). (It should be borne in mind that the Author is dealing here with cast iron and what follows does not apply to steel or non-ferrous alloys.) The work of Evans on fluidity of cast iron is very important in dealing with scrap diagnosis and imagined variables. Briefly, he found that no matter how he tried to obtain oxidized or "burnt" metal from the cupola, by blowing excess air, using a low coke-bed, etc., and by other means such as blowing air or oxygen through the metal, the fluidity of the metal obtained was purely a function of temperature and composition. The mysterious metal that "falls away" can be explained by analysis or temperature readings. He stressed also the other variables which may cause misruns—gating, ladle design and control, etc.

### Fluidity

Regarding the fluidity test itself, under laboratory conditions of control, reliable information can be obtained, but on the foundry floor variables creep in, even with such a well-designed gating system. Mould surface, too, plays an important part in the results obtained. V. Kondic states, in a paper to the Birmingham branch of the Institute regarding the spiral fluidity test, *that its sensitivity to melt quality lies well within the range of experimental scatter.* Now, if strictly controlled experiments cannot find this illusive melt-quality, it is not deemed feasible that any general foundry fluidity-test will do so.

When making a casting where variables such as gating, mould surface, pouring temperature, etc., are not under anything like the same degree of control as in the fluidity test, it seems unwise to bring such a factor as oxidized metal into a discussion of cold-shut or misrun castings.

If the composition or CE value of the castings do not conform to specification, that, of course, is another controllable factor; temperature is the most powerful single factor affecting the fluidity. If, therefore, this variable, *the unknown oxidized metal quality*, be removed the scrap investigations can be simplified.

### Gases

Similarly with gases in cast iron; from the result of the Joint Technical Committee on this subject, it seems fair to conclude that the amount of defects caused by gases picked up in the cupola is infinitesimal. If, however, the cupola-bed is damp, or damp ladles are used, then one can expect blowholes in a casting. These, however, are controllable factors—or they should be, even if it means pouring such metal into pig beds—yet how often can one find men pouring such metal into moulds in

the hope that the casting will turn out right? In this case that variable "metal-quality" is so dominant that a bad casting will result. Assume that these variables of damp cupola-bed and damp ladles are removed, small blowholes can still be obtained in the casting, but can a gassy test-piece be produced from a specially prepared test mould?

Sometimes too much is expected from molten cast iron. When a mould is damp and the metal has a long way to go, by the time it reaches the other end of the mould it has picked up hydrogen and become so "dull" that the slightest flutter on the mould surface leaves its mark on the casting. Although the metal initially may contain 0.002 per cent. of hydrogen, does it play a rôle of even minor significance when the metal/mould re-action or the pick-up of hydrogen from a damp mould or condensation of steam on the upper surface of the mould can take place? Herein lies another variable the significance of which has been overstated.

If the C.-E. value required and the temperature of the metal from the cupola be correct, the Author would be inclined to improve or control moulding, gating or pouring practice rather than get "grey hairs" in attempting to probe the mysteries of cupola melt-quality. However, perhaps the removal of these two "variables" might be received with mixed feelings—it is nice, sometimes, to have a mystery about the place, a Mister Nobody on which to pin some defective castings! Without wishing further to labour this point, the Author would refer to the lecture recently of F. Hudson on "Melt Quality in Non-ferrous Alloys," and the possibility of controlling, *in this case a real variable*, which would lead perhaps to a simplifying of foundry-scrap investigations in this field.

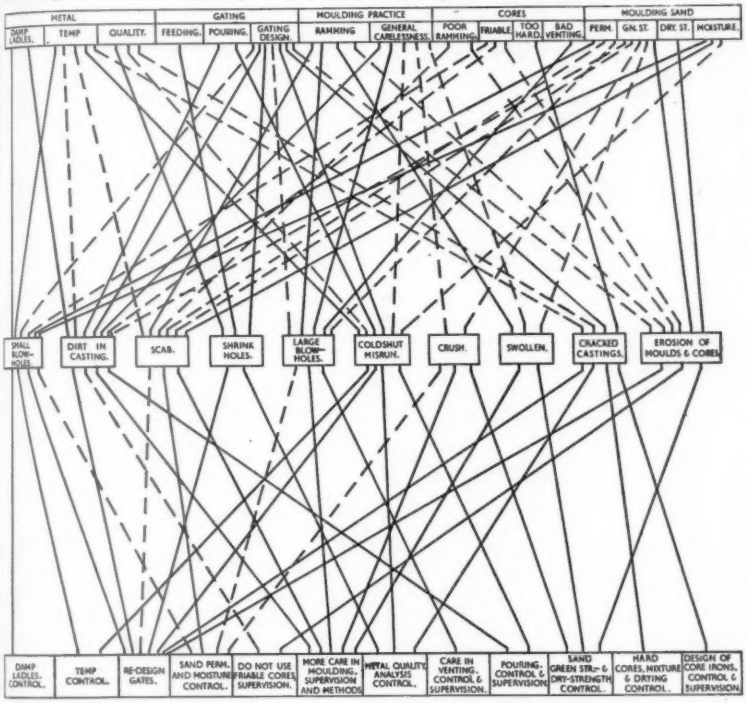



FIG. 5.—*Diagram indicating the complicated nature of the precautions necessary in making a casting.*

## Real Variables

### *Temperature*

When temperature is a cause of scrap, the solution is obvious. A range of temperature can be selected to suit each group of castings and sufficient control can be instituted in the foundry to see that castings are poured within the ranges of temperature specified. Can one consider the possibility of reducing this variable from a "potency" of two to a potency of three, or of reducing *p*, the probability. If temperature be controlled, and 10 castings are good, yet with two misrunning, cold-shut or burning-on takes place, then some other variable is responsible—*n*, the number of variables to be considered, is reduced by 1. This is not much, but when investigating scrap it makes the job easier.

### *Gating*

Where gating is rigidly controlled, *i.e.* where no moulder cuts his own gates, chooses his own risers, or designs his own head boxes, then this is no longer a variable (unless, of course, he carries a trowel or spoon in his pocket!).

Gating has become a very scientific subject with both simple *and* complex formulae postulated for determining the cross-sectional areas of downgates, runners, risers, etc. This is all to the good, when such information is correctly interpreted by foundrymen, and gives a much clearer picture of what happens in moulds when metal is poured in. Standardizing of gating, however, is more important initially than is experimenting too freely; experience is more likely to pay dividends and the two together, representing a combination of practice and theory, should solve any gating problem.

*Scrap Investigation*

If, however, the solution to a gating problem is found and not standardized or no methods are developed rigidly to control a standard, then most of the benefit of good gating is lost. When men cut their own gates, *p*, the probability of the variable being adverse, goes up and the potency of the variable usually increases also.

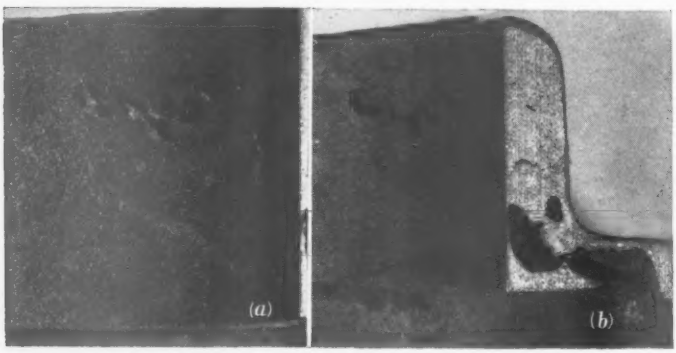
As most foundrymen know from experience, it is possible to make a good casting under very poor conditions of moulding practice—for example, poor sand or metal—by increasing the efficiency of the gating system, perhaps beyond economic limits, but nevertheless this stresses the point that if gating is a variable the analysis of the scrap situation is rendered much more difficult.

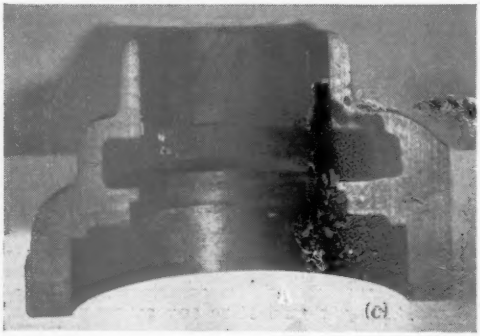
*Sand* is a variable with which all are acquainted. Certain properties of this material can be controlled or at least measured, but other properties are not so easily defined and are therefore more difficult to control.

**Controls**

Since the Author has been referring to controlling *p*, the probability and the potency of variables, it would not be out of place to deal with controls. There are various ways of looking at controls. One is apt to picture automatic-control mechanisms, laboratory personnel in white coats testing sand, metal and the like, but control may have a much wider meaning. To illustrate this point, in far-off days when men mixed their own sand, cut their own gates, took their own time and had to produce good castings or cease to be moulders, control did not seem to exist. But control of quality of tradesmen and labour was very much more rigid by—if the Author may misuse the phrase—natural selection of the best tradesmen. The tradesmen may not have heard of controls, but inherent in his skill he had control over his medium, such as an artist may have. His hand felt the sand and added water accordingly; he rammed his mould with an eye on the sand he used, the exact place in the mould he was ramming and the metal he was going to use; he cut his gates and risers and determined at what temperature he would pour the mould. If his control broke down, he had a bad casting, but in good tradesmen this control seldom did break down.

As batch milling of sand and its proper distribution, mechanical ramming and the other aids to increased output become prominent, the first stages in the transfer of control from the individual moulder took place. It is germane to ask if the quality of tradesmen deteriorated because of external control, or whether external control became necessary due to a lowering of skill. This is no reflection on present-day good tradesmen and the Author is well aware that dilution and division of labour has had a vital part in this process. However, where some controls are taken from skilled craftsmen, it may upset the fine balance of their own controls. When control of some variable is transferred from the individual to an external source, due care and



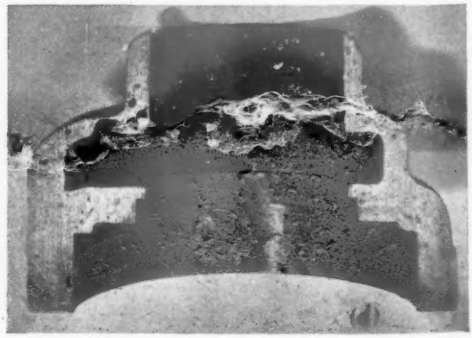




FIG. 6.—(*a*) *Bore of a simple casting partly machined and showing holes, apparently due to shrinkage.* FIG. 6 (*b*), (*c*) AND (*d*).—*Sections of the same casting, indicating that the holes in the bore are caused by gas from the core.*

thought should be given to the psychological affect it may have. The Author queries if founders have paid sufficient attention to this transfer of controls and how it operates.

Control of variables, of course, has to be realistic and the law of diminishing-returns applies. Making a control too precise or having an unnecessary narrow limit may have an opposite affect in practice to that desired. If set limits are overstepped and men see no material difference in the casting as a result, they tend to underestimate the potential danger and ignore the control. One may over-control some factors and under-control others, but control for controls sake, should be avoided like the plague.

### New Materials or Methods

When investigating a new method or material, it is usual to carry out laboratory experiments on the process and find out its virtues and vices. It is then tested, supposedly under normal foundry conditions — but are these conditions always normal? Often, there are so many people popping about with an interest in the new process that control is not at all normal. Exact amounts of this and that are mixed, scales and containers are checked and the men working on the job are subjected to much more unseen supervision than

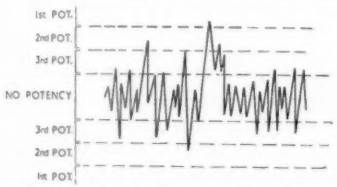



FIG. 7.—*Graph of the degree of variance from a given value, indicating first, second, and third orders of potency.*

normally. Then, if the process is finally adopted, these " unseen " controls slip off, and trouble arises. In such a case one may check metal, sand, methods and a whole host of factors and nothing seems different or perhaps nothing *is* different, except that the men have really returned to what is *normal practice*. In effect, the method was too sensitive to normal variations to be met with in foundries. It is suggested here, that it is imperative really to check controls and estimate whether in the foundry they are adequate to deal with a new process which has a higher sensitivity to variables.

The foundry industry has been lucky in having some materials which permit a wide latitude in their use. The Scottish branch president, in his address during the current session mentioned that if founders had never used natural moulding sand, and someone introduced it—with all its virtues—and it was given as much attention as new methods, it would be surprising just how wonderful natural sand turned out to be. There is virtue in a material which can stand a considerable amount of abuse.

### Difficulties of Diagnosis

The Author has mentioned previously the danger of wrong diagnosis of a fault while investigating scrap. One example only will be dealt with, since this is not a paper on diagnosis as such. In Fig. 6 (*a*) is shown the bore of a simple casting which has been partly machined; a series of holes appear in the bore. Almost invariably such rough, long holes as those shown are classed as shrinkage defects when seen on a machined surface. However, on cutting through the casting the defects appear as shown in Figs. 6 (*b*), (*c*) and (*d*), where it is obvious that the main trouble is gas from the core, though it is not so obvious when the entry of the gas cannot be detected. Whether the core " blew " and then the gas remained in the casting, or whether the back pressure of the gas in the core, plus the tendency to produce a hot spot, caused the same sort of phenomenon as is experienced with a Williams atmospheric feeder, the Author leaves for readers to decide.

Castings have been seen where the effect of a build-up of gas pressure in a core *after* the casting has commenced to solidify has been sufficient to " blow " its way into the metal and against the metal pressure. To where does the metal which is displaced go? Possibly, the solid skin of the casting shrinking away from the mould wall due to solid contraction loses the support of the mould. This weakened wall of metal may be insufficiently strong to resist the pressure of the gas pushing in from the core, and entry of the gas at a hot spot causes the casting to swell, and perhaps to regain its contact with the mould wall. Internal shrinkage which must occur, and which may either be diffused throughout the main body of the casting or supplied with fresh metal from above, is localized in the vicinity of the blowhole and the appearance of such a hole can easily mislead one into thinking in terms of shrinkage only.

If a Williams riser can do this with atmospheric pressure, what might not happen when a core insufficiently vented creates its peak gas-pressure some time after the casting has commenced to solidify? The cure for this type of defect is not a question solely of adequate feeding, metal head-pressure, composition, or even temperature gradients, but a case of more efficient venting. If one could only create a vacuum in the core after casting, equal to the vacuum created by internal shrinkage, fewer of this type of defect might be encountered. The size of a drawn hole, or the amount of variations of size of these holes in otherwise identical castings, should indicate whether gas pressure or atmospheric pressure plays a dominant rôle in the shrinkage defect, *i.e.*, large variations would indicate that gas pressure is partly responsible.

### Acknowledgment

As a result of his treating this subject in a slightly unorthodox manner, the Author hopes readers will derive some benefit. He himself, at any rate, feels he has a better picture in his mind of what goes on " under his nose," but beyond his

*Scrap Investigation*

eyes. He thanks the directors of Mavor & Coulson, Limited, for permission to present this Paper, and

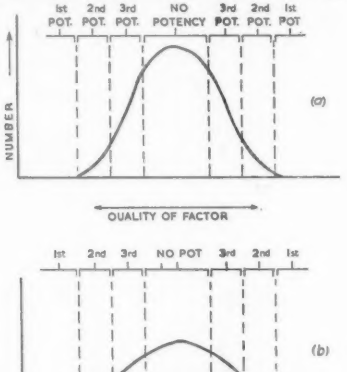



FIG. 8 (*a*) AND (*b*).—*Potency factors from Fig. 7 transferred to a distribution curve. The total area under the curve depicts the total probabilities;* (*c*) *shows the effect when the distribution curve is biased.*

for the co-operation of the foundry manager and his staff for tolerating and even encouraging such unorthodox schemes as those reported.

## ADDENDUM

Subsequent to the presentation of this Paper to the Scottish branch of the Institute, the Author has prepared an Addendum which examines further, on a mathematical basis, the probability laws governing the production of scrap castings. The main conclusions resulting from this investigation indicate that in a chronic scrap situation, if one assumes a normal distribution of the quality of each factor about (or away from) the ideal quality of that factor, the following results are arrived at:—

> 10 per cent. of the total chronic scrap is due to factors with a potency of the first order, 15 per cent. due to second-order potencies, 60 per cent. to the third-order potencies and 15 per cent. to a combination of second- and third-order potencies.

These rough figures are arrived at from a corrected and refined version of the crude picture of probabilities given in the lecture. The formula in the Addendum accommodates different probabilities for each variable factor and differing probabilities for each potency in each factor. The cancelling effect of variables and the combination of second- and third-order potencies is also taken into consideration.

Unfortunately, the use of the formula other than as an aid to thinking about scrap is too onerous for general foundry use. The main obstacle is not the formula itself but the assessment of second- and third-order potencies and the fact that such potencies vary for different types of castings.

[A copy of this Addendum has been lodged with the secretary of the Institute and is available on loan to readers who are interested in following-up these aspects.]

## Price-freeze Campaign

The campaign to effect a period of price stabilization is now really getting under way. Quite recently the National Coal Board and the Central Electricity Authority both announced that they would endeavour not to raise their prices at least until after March 31 next year. On Tuesday of last week, after a meeting between the leaders of nationalized industry and Sir Anthony Eden and other Ministers, the Gas Council stated that all Area Gas Boards, after making price revisions to cover increased working costs as at June 1, would keep prices unchanged at least until the end of the current financial year, unless unforeseen circumstances arose. The North of Scotland Hydro-Electric Board also reported last Tuesday that it had decided to stabilize prices, while the British Transport Commission made an announcement to this effect on the following day.

In his statement giving details of the price freeze to be applied on the railways, Sir Brian Robertson, chairman of the BTC, said that freight charges would not be increased again this year provided that as a result of the reassessment of the commission's financial position, now being made, a course of action consistent with its statutory obligations and a proper development of the transport undertakings could be worked out and adopted. There would be no general increase in passenger fares, although local adjustments would not be covered by this undertaking. The price standstill did not apply to the commission's other activities such as canals, docks, and road haulage.

Private industry, which told the Prime Minister at a meeting on June 11 that it could not achieve price stability without the co-operation of the State boards, now seems to be following the lead given by the latter. The Cement Makers' Federation announced on June 26, that the price of Portland cement would be increased by 3s. a ton from July 1, but that, if possible, in view of the statements by the coal and electricity industries, the new prices would not be increased for at least 12 months.

## Institute Elects New Members

At the Council meeting held on June 12, 1956, during the conference at Cardiff, the following were admitted to membership of the Institute of British Foundrymen in the grades indicated below:—

AS MEMBERS

A. O. Blunt, Wallwin Foundries, Limited, Warwick.
G. W. Bouckley, Tyseley Foundry, Limited, Birmingham.
N. J. M. Brelaz, Standard Chemical Company, Pty., Limited, Melbourne, Australia.
G. H. Charsley, Trent Foundries, Limited, Wolstanton, Stoke-on-Trent.
D. Epstein, F. & M. Supplies, Limited, London, E.C.2.
G. Flynn, Humber, Limited, Coventry.
J. S. Goodwin, R. Goodwin & Sons, Limited, Hanley, Stoke-on-Trent.
J. S. Gosling, Witbank Foundry, Pty., Limited, S. Africa.
D. J. F. Guthrie, General Electric Company, Limited, Birmingham, 6.
I. McHamilton, Crompton & Walker, Pty., Limited, Bankstown, N.S.W., Australia.
R. Hyde, Harvey & Longstaffe, Limited, Ancoats, Manchester.
R. S. Lovatt, Wedgewood Foundries, Limited, Stoke-on-Trent.
A. Newell, Sandholme Iron Company, Limited, Todmorden, Lancs.

TRANSFERS FROM ASSOCIATE MEMBER TO MEMBER

A. B. Calvert, W. & T. Avery, Limited, Walsall.

AS ASSOCIATE MEMBERS

T. Alfonso, Patternmakers, Limited, Coventry.
R. A. Ashworth, Jackson & Brother, Limited, Bolton.
T. Bennett, Storey Foundry Company, Limited, Stockport.
V. R. Beresford, Dorset Iron Foundry Company, Limited, Poole, Dorset.
A. C. M. Crombie, Rhodesia Railways, Bulawayo, Southern Rhodesia.
W. Gallimore, Storey Foundry Company, Limited, Stockport.
G. W. Kendrick, Harvey & Longstaffe, Limited.
C. G. Kimberley, Sterling Metals, Limited, Coventry.
W. A. Kirk, Sterling Metals, Limited, Nuneaton.
D. C. Lambert, Charles Roberts & Company, Limited, Wakefield, Yorks.
J. C. Lankenau, Alrite Engineering Supplies, Limited, Johannesburg, South Africa.
A. E. Machin, Wedgewood Foundries, Limited.
R. A. Reekie, I.C.I.A.N.Z., Limited, Deer Park, Victoria, Australia.
S. J. Robinson, Sterling Metals, Limited, Coventry.
G. H. Rutter, Wedgewood Foundries, Limited.
L. E. Rust, D. Napier & Son, Limited, London, W.3.
P. K. Sellers, Broom & Wade, Limited, High Wycombe, Bucks.
R. S. I. Smith, Air Control Installations, Limited, Ruislip, Middlesex.
W. F. Sutherland, N. C. Holmes & Company, Limited, Huddersfield, Yorks.
A. G. Tollerfield, Grove Iron Works, Bridport, Dorset.
J. W. Tomkins, K. & L. Steelfounders & Engineers, Limited, Letchworth, Herts.
H. Vernon, Wedgewood Foundries, Limited.
L. N. Vyas, Northern Railway Workshops, Jodhpur, India.
R. E. J. Wells, Jones & Shipman, Limited, Leicester.
F. V. Weng, C.M.E. Dept., Malayan Railway, Kuala Lumpur.

TRANSFERS FROM ASSOCIATE TO ASSOCIATE MEMBER

P. E. Brookhouse, Phosphor Bronze Company, Limited, Birmingham, 5.
L. J. Crowe, Renshaw Foundry, Limited, Staines, Middlesex.
D. E. Fardoe, Morris Motors, Limited, Coventry.
A. Riley, Sterling Metals, Limited, Coventry.

AS ASSOCIATES (over 21)

S. C. Butt, Ruston & Hornsby, Limited, Lincoln.
P. A. M. Cooke, D. Napier & Son, Limited, London, W.3.
J. A. Edwards, Ruston & Hornsby, Limited.
J. R. Ellis, English Electric Company, Limited, Bradford, Yorks.
D. Green, Ruston & Hornsby, Limited.
F. S. Malt, Ruston & Hornsby, Limited.
J. Musson, Stanton Ironworks Company, Limited, near Nottingham.
H. Parkinson, Ruston & Hornsby, Limited.
W. R. Reeve, Ruston & Hornsby, Limited.
G. H. Robson, Ransomes & Rapier, Limited, Ipswich.
R. C. J. Swanborough, Broom & Wade, Limited.

AS ASSOCIATES (under 21)

J. H. Hurt, Stanton Ironworks Company, Limited.
K. R. Reynolds, English Electric Company, Limited, Rugby.
A. M. Sweed, J. I. Thornycroft & Company, Limited, Southampton.
R. J. B. Terry, J. H. May, Clerkenwell, London, E.C.1.

## Midlands Industry

Addressing the Midland Regional Board for Industry in Birmingham on June 22, Mr. A. R. W. Low, Minister of State, Board of Trade, predicted a greater switch of resources of men and materials to the successful exporting industries in the last part of this year. Earlier the Board had received a report that the number of workers in the region on short time had reached 48,100 at the end of May. Mr. Low said that the trade figures for May confirmed the evidence of the earlier months. There was a steady increase in the volume as well as to the value of our exports. The figures were "mildly encouraging" but did not represent the marked increase in exports which we had to achieve.

The answer to the question as to why we had not done better lay in the single word "inflation." The success of the measures already taken would do more than the Government could do in any other way to help British industry to sell at competitive prices, at shorter delivery dates and with increasing figures. With regard to the future, there was ground for expecting a marked improvement in sales efforts, as a reduction in the excessive home demand removed the pull of the home market. "If we are to have the marked increase in our exports which we must have, there must be the switch of resources over to the exports, particularly for the engineering industry," Mr. Low went on. There was nothing new about the need for flexibility in our industrial production. Nowhere more than in the Midlands had traditional skill been adapted to meet fundamental changes in world demand over the last 50 years. In the last 18 months he had been in 18 different countries, Mr. Low said, and had seen for himself the opportunities in those expanding markets. All he had been told proved to him that there was no substitute for personal visits by industrial leaders to these markets. Manufacturers should give greater publicity to their successes—"We still read too much of what Britain has not done and too little of the hundreds of orders placed and contracts won by British firms, large and small. Buyers in world markets judge us by what we say about ourselves, and modesty and self criticism that may become us here, win us no orders and few friends overseas."

The report of the labour position in the Midlands revealed that on May 14, the register of unemployed in the region totalled 21,938. Vacant jobs in the five Midland counties at the end of May totalled 39,590—a decrease of 1,325 during the month and a decrease of 2,102 since the beginning of April.

## Draft Standard for Patterns

A draft standard for wooden pattern equipment for foundries (Revision of B.S. 467:1952) has been prepared by BSI Technical Committee MEE/22—Foundry Equipment and Foundry Patterns, and in accordance with the procedure of the Institution, is now being circulated for technical comment to industry and others concerned, and also to members of various committees of the Institution who may be interested in the draft, either in whole or in part. The Committee would appreciate any views on this document, which should be submitted before July 24, 1956. If views are not received by that date, it will be assumed that comment is not desired. The draft should not yet be regarded or used as a British Standard and any queries should be addressed to the Committee secretary, Mr. J. A. Bullock, at the British Standards Institution, 2, Park Street, London, W.1.

# Law Cases

## Pourer not Wearing Goggles—Eye Injury

A Derby man employed as a foundry pourer, in September, 1954, was splashed in the eye by molten metal and as a result spent a month in hospital. At the Derbyshire Assizes on June 12, his claim for damages against his firm was dismissed and judgment, with costs, was awarded to defendants. It appeared that during the course of his work the man, Theodore Anderson, had to remove solidified metal from a crucible and put it on to a steel plate. The molten metal splashed out of a crucible, dropped on to the steel plate and spluttered into his left eye.

Mr. Richard O'Sullivan, Q.C., for Anderson, said that as a result of the serious injury to his left eye, plaintiff was in hospital for a month and he was unable to work for eight months—then he was forced to get another job at a less wage. In fact he was suffering a loss of wages of 16s. 9d. a week.

Anderson said he had been employed by the same firm for about 36 years, for the last ten years in the lead and bronze department, casting bearings for engines. On the day of the accident he had some molten metal in a crucible and, when it had solidified he was going to put it on to a steel plate. "The metal in the top of the crucible was black and, because of this and the time it had been standing, I thought it was quite in order to put it on the plate," Anderson told the Court. "I thought it had solidified but I must have misjudged because, when I was about four inches away, some of the metal touched the plate and splashed into my eye. It also set my clothes on fire." He added that he was not wearing goggles at the time. He had been issued with a pair some years before, but had never had any instructions as to when they should be worn. "If I had known that the metal was not solidified I would not have taken it out," he said. He then said that the metal had spluttered into his eye because the steel plate was damp before, but on this occasion did not look to see whether it was damp or not.

Mr. Flint, for the company, asked the plaintiff: "Did this accident happen because you made a mistake in thinking that the metal had solidified?" Anderson replied: "I must have misjudged. I would have worn my goggles if I had thought that the metal was molten." Mr. Flint submitted that the firm had no case to answer.

## Electrocution by Crane Wires

There was no direct evidence as to what happened when George Henry Simpson, 56, works labourer, was found electrocuted after being told to load castings on to a lorry at a foundry in Chesterfield. This was stated by the coroner, Mr. Michael Swanwick, at the inquest on June 14, when a verdict of "Accidental Death" was returned. Simpson's cap was found on the access platform of a crane over the spot where his body was found, and the jury considered that he had come into contact with overhead wires and recommended that in future such wires should be protected.

Kenneth Wass, the yard foreman, said Simpson, with another man, had the job of loading a lorry with castings. When he went into the yard he noticed Simpson was missing and the other man did not know where he was. Wass said Simpson was a very conscientious worker and would do everything to complete his work in the shortest possible time. He went on, "It may have been that Simpson went into the foundry shop to find some chains to assist with the loading. He may have seen the chains hanging on the crane hook and went up on to the crane platform to fetch them." Arthur Pierce, works electrician, said there were three unguarded power lines which supplied power to the cranes. They were just above the crane platform. He said there was no warning notice, and in reply to the coroner said he considered it unsafe to have the wires unprotected but nothing could be done about it. Mr. Bertram Mather, for the firm, stated that the wires had since been removed 35 ft. from the area in question and there was no further likelihood of a recurrence.

## Steel Company Wins Appeal

The First Division of the Scottish Court of Session has upheld an appeal against an award of £3,000 made by Lord Blades to the widow of a steelworker and her family in April last year. The husband, Mr. Alexander Watson Nicholson, who died in 1951 from pneumoconiosis, had been employed in a Scottish steel foundry. His work consisted of operating a pneumatic hammer to remove sand from steel castings.

His widow, Mrs. Annie Nicholson, of Wotherspoon Crescent, Armadale, sued the company for £3,000 for herself and £2,450 for her four children. She averred that the company should have provided adequate ventilation in the dressing shop where her husband was employed. The defendants maintained that there was adequate ventilation and that the precautions taken were reasonably adequate.

Lord Blades held that the company had failed in its duty and had made the award. But Lord Clyde, the Lord President, held at the appeal that the company was not in breach of the Factories Act regulations, and overturned Lord Blades's decision. Lords Carmont, Russell, and Sorn concurred.

Lord Blades had ruled that the company was in breach of the factory regulations because it had no dust-extraction plant on the grinders in the dressing shop. The Lord President said that there was evidence in the case to show that it was not practicable to fit the exhaust apparatus to the grinders, and, in his opinion, the company was not in breach of the factory regulations.

## £20,000 Fine for Illegal Scrap Exports

Fines totalling £20,000, with the option of 12 months' imprisonment, were imposed on Roger Muir Easdale (49), who pleaded guilty at Glasgow Sheriff Court in attempting to evade restrictions by exporting scrap metal worth £26,837 without a licence. Easdale is a partner in E. M. Easdale & Company, metal and scrap merchants and exporters, of Glasgow.

It was stated in the charge that there were a number of shipments between June 3 and November, 1953, and the value of each varied. The goods consisted of drums of gunmetal scrap, brass scrap, and copper scrap. The scrap went to a firm in Hungary.

Mr. Robert Macdonald, prosecuting, said that the exportations were achieved by deceitful means. The shipments had gone from Grangemouth (Stirlingshire) to Rotterdam, and from there by land to Budapest.

Mr. Harold Leslie, defending, said there had been no deceit by Easdale. In certain cases it had been difficult to decide which goods were usable and which were scrap under the Export of Goods Order. The authorities had now conceded that at least 40 per cent. of the goods which had been shipped were not subject to prohibition. The amount involved in the case was only 3 per cent. of the total tonnage dealt with by the firm.

# Internal Stress in Castings

## *Second Report of IBF Technical Council Sub-committee T.S.32**

*After reviewing earlier work, the Report describes experiments on casting small triangular grey-iron grids in warm moulds, with consequent reduction in residual stress. Similar grids of larger size were cast with a series of varying sectional-thicknesses in the centre limb of the grid and showed tensile internal-stresses in the heavier sections; the greater the difference in sectional thickness existing within the casting, the higher was the stress. The stress distribution was also determined in a number of discs cast in varying thicknesses in mild steel, austenitic steel and cast iron. In all cases, the magnitude of the internal stresses was found to depend mainly upon the magnitude of the temperature differences existing within the cooling casting. The mechanism by which internal stresses form is considered in some detail and other manifestations of strains arising during cooling are dealt with briefly. Some general recommendations are made on methods for reduction of internal stress.*

### Terms of Reference

Following the work of technical sub-committee T.S.18, technical sub-committee T.S.32 was established by the Technical Council of the Institute of British Foundrymen in 1949 with terms of reference "to investigate the problems of internal stress in castings." Its first report[1] was published in 1952.

### INTRODUCTION

The presence of internal stresses (perhaps better described as residual stresses) in castings may lead to unexpected cracking or distortion at any stage in the life of the casting. Many factors control the incidence and magnitude of the stresses, not least being those associated with the design. Each casting must be considered on its own merits; production procedures which are satisfactory for one casting may be quite unsuitable for another. The purpose of the sub-committee's work has been to lay down some principles of general application and to establish the relative importance of the main factors influencing residual stresses.

### REVIEW OF PREVIOUS WORK

The first report[1] of the sub-committee described work on straight-brass bars with and without flanges at each end, on triangular-grid castings in aluminium alloys and in steel, and on hollow cylinders of various dimensions in cast iron. The report pointed out that elastic strains in castings which were balanced by the resistance of the mould material disappeared when the casting was removed from the mould. It was concluded that temperature differences within the casting were the most important source of residual internal stresses and that any steps taken in the foundry to reduce the temperature differences tended to reduce the residual internal stresses. A method of reducing temperature differences was to strip castings from the mould at a high temperature, as was first disclosed in the report of T.S.18.[2] The report also drew attention to the possible effects of restraint by the material of the mould and to the effect of phase transformations. In all cases, the general mechanism by which internal stresses were formed comprised compression and plastic deformation of a part of the casting at high temperatures followed at lower temperatures by the development of tensile stresses, usually in the same part of the casting.

Dodd[3] carried out experiments with the aluminium alloy RR.59, using grids with three parallel limbs, the centre limb being changeable to provide varying cross-sectional areas, designed to develop varying temperature differences and, therefore, varying internal stresses. The results showed that internal stress did increase, as expected, with increase in the ratio between the cross-sectional areas of the centre limb and the outer limbs, to a maximum when the cross section of the centre limb was 2.5 times the cross-sectional area of the

*Submitted for consideration at the annual conference of the Institute of British Foundrymen last month in Cardiff.

CONSTITUTION OF SUB-COMMITTEE T.S.32

*M. M. Hallett, M.Sc., F.I.M. (chairman).* *H. T. Angus, Ph.D., M.Sc.*
*A. Braybrook, A.Met., A.I.M.* *A. B. Everest, Ph.D., B.Sc., F.I.M.*
*R. L. Handley, B.Sc. (Tech.), A.M.I.E.E.* *S. Hughes (Gardom student).*
*V. Kondic, Ph.D., B.Sc.* *W. M. Lord, B.Sc. (Tech.), A.I.M.*
*R. N. Parkins, Ph.D., B.Sc., A.I.M.* *C. A. Payne, B.Sc. (corresponding member).*
*R. W. Ruddle, M.A., F.I.M.* *H. Sunderland.*
*G. Lambert (sub-committee secretary).*

*In addition, valuable contributions to the work of the sub-committee have been made by Dr. R. A. Dodd, Mr. M. C. Oldham, Mr. J. J. Pick and Mr. C. R. Tottle, who have all been members for varying periods.*

outer limb. He also showed on the same grid that the internal stress increased with increasing moisture-content of the sand, with increase in stripping time and slowly with increase in pouring temperature. No increase in internal stress was observed with increasing hardness of green-sand moulds or with increasing compressive strength of dry-sand moulds. All the results in this investigation thus pointed to differences in temperature as being the main factor in determining the magnitude of internal stresses.

Parkins and Cowan[4] dealt with the effect of sand properties on the amount of plastic strain undergone in the cooling of castings. Using bars flanged at each end, they found that the amount of plastic deformation tended to be greater in harder sands and less in weak sands, although this tendency was not absolutely consistent in all cases. Tests on thin-walled cylinders showed more plastic strain when these were cast around hard cores than when cast around soft cores. In all these cylinders,

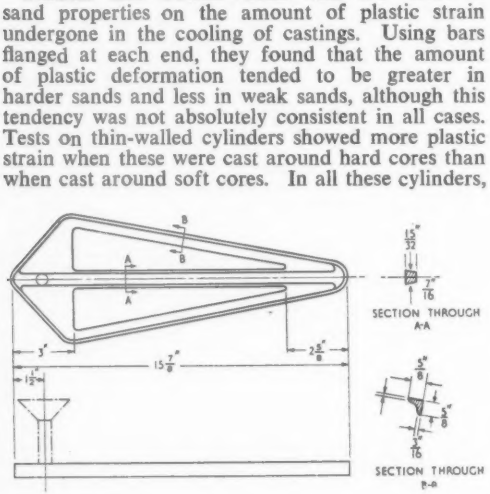



FIG. 1.—*Design and dimensions of the small triangular-grid casting.*

no internal stress was revealed by slitting after stripping the cylinders from the mould. Further experiments indicated that mould friction could play a part, especially if the sand was unusually plastic, permitting easier slip.

In a particularly illuminating paper, Parkins and Cowan[5] studied the effect of making both triangular and rectangular-grid castings in Y-alloy, brass and cast iron in moulds prepared from a series of sands varying in strength. The temperature differences existing during cooling in the mould, were measured and also in the same castings when they were reheated to various temperatures and cooled in air. The tests showed that internal stresses were directly related to temperature differences in the casting. Phase transformations could also influence internal stresses, both because of their effect on temperature differences and because of concurrent volume changes. The effect of restraint by the sand mould on the magnitude of internal stresses in castings was more complex because the sands studied generally showed larger variations in their strength at high temperatures than at room temperatures and, of the three alloys studied, only cast iron raised the sand temperature to the extent needed to bring out the difference in sand strength. The influence of the properties of the sand in a mould is, therefore, only likely to be felt when the temperature differences in a casting occur at relatively high temperatures. Even when considering the effect of the strength properties of the sand, the main factor in reduction of internal stresses in castings is reduction of the temperature differences which occur in those castings, since the influence of mould materials and of phase transformations will usually be felt only if temperature differences are also present.

The conception of the grid casting as a means of investigating internal stresses was first put forward in this country by Longden.[6] Another important paper which provides much information on the question of cracking in light castings was published by Angus.[7]

## EXPERIMENTAL WORK

Part of the experimental work considered by the sub-committee since the appearance of the first report has been published separately under the references quoted above. In addition to this work, investigations have been carried out on the original small triangular grids cast into moulds which were heated to various moderately-elevated temperatures. By casting into warm moulds, the temperature differences between the different parts of the castings should be reduced and therefore the internal stresses should also be reduced. The work was designed to see whether this was in fact the case.

It has been suggested in some quarters that exposure to sub-zero temperatures reduces internal stresses. It was difficult to see why this should be so but a few tests were performed on the grid castings to check the possibility. It also seemed desirable to study the scale effect by measuring the stresses in triangular-grid castings of the same type as those previously employed but of a considerably larger size. Work on these larger castings included variations in the ratio between the cross-sectional areas of the thick and thin limbs of the casting. Since troubles are often experienced in the foundry with cracking of flat disc-castings, the stress distribution has been determined in flat circular discs cast in grey iron, mild steel and austenitic steel. The results of these experiments are given below.

### I—Tests on Triangular-grid Castings

(*a*) *Effect of Casting in Hot Moulds.*

The grid casting was of the same general dimensions as that used in the first report of the sub-committee[1] and is illustrated in Fig. 1. Since it was intended to carry out stress measurements by means of strain gauges, the best possible surface-finish was desired and the casting was run from one end instead of directly into the centre limb as illustrated in Fig. 3 of the first report. This may have reduced to some extent the temperature differences between the centre and outer limbs but the main flow of metal still passed along the centre limb and the casting certainly developed considerable internal stress. The moulds were prepared under comparable conditions and rammed to the same density. The castings were within normal size variations for commercial castings, *e.g.*, on the outer

limbs the vertical flange showed a maximum variation of 0.009 in. on the nominal 0.17-in. thickness and the horizontal flange on the outer limbs showed a maximum variation of 0.016 in. across the joint on the nominal thickness of 0.20 in. There was a slight amount of flash, particularly in the hottest moulds owing to the friability of the edges of the sand mould after pre-heating.

Six grid castings were prepared in an iron of the following composition:—Total carbon, 3.08; silicon, 2.55; manganese, 0.64; sulphur, 0.057; and phosphorus, 0.22 per cent. In the centre limb, all the castings showed fine interdendritic graphite in a pearlitic matrix and the structure did not vary very much with temperature of mould. The outer limbs showed chill on the edges of the flanges, the amount of chill decreasing with increasing mould temperature. All the castings were in dry sand, two being made in moulds heated to 400 deg. C., two in moulds heated to 200 deg. C., and two in moulds at room temperature. In each case, the moulds were actually heated 60 to 70 deg. above the specified temperature to allow for the time lag in removing them from the oven and the casting operation. The casting temperature was 1,350 deg. C.

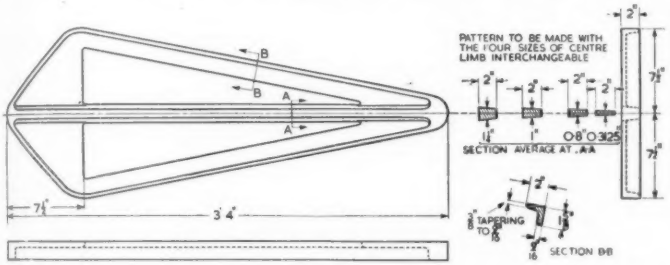



FIG. 2.—*Large triangular-grid casting, cast two per box, well separated so as to permit independent cooling.*

One casting made at each temperature was selected and lines scribed on the centre bar. The centre bar was then cut between the scribed lines and the change in length measured. The second casting made at each temperature was fitted with electrical strain gauges and the strain measured after cutting the centre member. Tensile test-pieces were also prepared from the centre member and subjected to a tensile test. From the results of the tensile test, the modulus of elasticity was determined for each casting and from this and the measured strain, the internal stress was calculated. The results are quoted below, the figures in the second column being the strain measurements determined between the scribed lines and the results in the third column the internal-stress measurements calculated from the electrical-strain-gauge data.

| Mould temperature. | Change in length on slitting. | Internal stress. |
|---|---|---|
| | mm. | tons per sq. in. |
| Room temperature .. .. | 0.78 | 8.90 |
| 200 deg. C. .. .. | 0.43 | 5.18 |
| 400 deg. C. .. .. | 0.18 | 3.59 |

No quantitative significance is attached to the figures quoted in the second column but they do provide a qualitative indication of the same phenomena as the strain gauge measurements reveal accurately as noted in the third column. It is clear that casting into hot moulds substantially reduces the amount of internal stress and that this reduction in stress is due to the reduction in temperature differences between the centre and outer limbs of the casting.

(*b*) *Effect of Sub-zero Temperatures.*

A set of grids to the design shown in Fig. 1 was cast in iron of the following composition:—Total carbon, 3.28; silicon, 2.55; manganese, 0.56; sulphur, 0.069; and phosphorus, 1.19 per cent. The castings showed a completely grey structure in all sections. Three of the castings were immersed in liquid oxygen (−183 deg. C.). Two broke on immersion, but the third casting was quenched six times in succession allowing it to rise to room temperature after each immersion. After this treatment, the casting was uncracked and was left overnight at room temperature. In the morning it was found to have broken.

The cracking on immersion of the two castings is presumably connected with the development of temperature differences during quenching. No rational explanation can be provided for the behaviour of the third casting as it would have been thought that the thermal stresses introduced during the drastic cooling-operations would have greatly surpassed in magnitude any which could have arisen during standing overnight. Certainly exposure to sub-zero temperatures does not lead to relief of stress.

(*c*) *Effect of Structure on Stresses.*

During the preliminary work on the grid castings leading up to the experiments described on hot moulds and on low temperature treatments, a number of castings were made varying in analysis and there appeared to be a relationship between the structure of the castings and the amount of internal

TABLE I.—*Effect of Composition and Structure on Cracking.*

| Melt No. | Y.555 | Y.356 | Y.425 | Y.455 | Y.581 |
|---|---|---|---|---|---|
| | per cent. | per cent. | per cent. | per cent. | per cent. |
| T.C. .. | 3.12 | 3.07 | 3.31 | 3.28 | 3.08 |
| Si .. | 1.81 | 1.92 | 2.19 | 2.55 | 2.55 |
| Mn .. | 0.47 | 0.42 | 0.76 | 0.56 | 0.64 |
| S .. | 0.061 | 0.065 | 0.055 | 0.069 | 0.057 |
| P .. | 1.05 | 1.10 | 1.20 | 1.19 | 0.22 |
| Carbon Equivalent | 4.07 | 4.08 | 4.46 | 4.53 | 4.00 |
| Structure of side members | Heavy chill | Chill/ mottle | Edge chill | Grey | Edge chill |
| Amount of cracking | All cracked | 5 out of 6 | All cracked | Uncracked | Uncracked |

stress developed. In general, when the side members of the grid showed a heavy chill structure, the castings usually cracked in the mould. This cracking occurred in the web at the wider end of the grid at the junction between the side member and the web. Table I indicates this tendency.

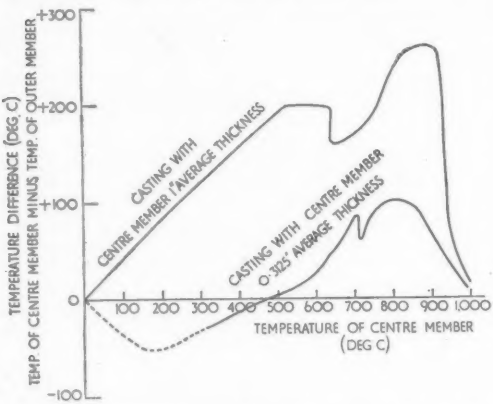

TEMPERATURE DIFFERENCE (DEG. C)
TEMP. OF CENTRE MEMBER MINUS TEMP. OF OUTER MEMBER
+300
+200
+100
0
-100
CASTING WITH CENTRE MEMBER 1"AVERAGE THICKNESS
CASTING WITH CENTRE MEMBER 0·3125 AVERAGE THICKNESS
100 200 300 400 500 600 700 800 900 1000
TEMPERATURE OF CENTRE MEMBER (DEG C)

FIG. 3.—*Temperature differences recorded during casting of large-grid test-pieces.*

Considering the high-phosphorus irons, with the exception of a single casting from melt Y.356, all the grids with appreciable chilling on the side member (or with low Carbon-Equivalent values, as pointed out by Angus[7]) cracked in the mould. Where the side members were grey, the castings did not crack. In all cases, the centre members were grey, although the graphite size varied somewhat with composition. The single low-phosphorus iron appears to be less prone to cracking for a given structure than the high-phosphorus irons.

The tendency to crack (and, therefore, in general the magnitude of the internal stresses) in the castings showing chilled outer members may be explained by reference to the lower ability of white iron to deform plastically and so to relieve local stress concentrations at the junction of the limb with the web.

*(d) Tests on Large-grid Castings.*

All the work so far described in this Report and in the first report of the sub-committee has been on triangular, three-limbed grid castings approximately 15-in. long. It was thought desirable to extend the work to larger-grid castings to see whether there was any scale effect. It was decided to extract the maximum amount of information possible from these tests by arranging for the centre limb to be made in four interchangeable sizes, thus permitting a range of ratios between the cross-sectional areas of the inner and outer limbs to be studied. Temperature records of all castings during cooling in the mould were planned.

Considerable importance was attached to uniformity of casting conditions but it was not easy to find a foundry prepared to put the necessary large machine-moulding capacity at the disposal of the sub-committee. Eventually a solution to this problem was found and the moulds were rammed with the aid of an impeller-rammer and the patterns extracted on a stripping machine.

The design of the grid is illustrated in Fig. 2 and by using 56-in. by 52-in. boxes it was possible to cast two grids in each box at such a distance from each other that they cooled independently. The two grids were arranged in the box end for end and did not approach closer to each other than 16 in., and were also remote from the edge of the box. They were poured independently to avoid any possible hindrance to mutual contraction, the pouring temperature being 1,370 deg. C.

The sand was a mixture of two parts of Mansfield sand with six parts of Weaste sand, four parts of floor sand, two parts of dry manure with about a 6 per cent. addition of fine coal-dust and a water content of about 8 per cent. The green compression strength was about 7 lb. per sq. in. with a permeability of 35. The composition and tensile strength of the castings are quoted below:

| Nominal thickness of centre limb in ins. | 0.3125 in. | 0.8 in. | 1.0 in. | 1.25 in. |
|---|---|---|---|---|
| Composition, per cent. | | | | |
| T.C. .. .. .. | 3.38 | 3.42 | 3.42 | 3.39 |
| Si .. .. .. | 2.39 | 2.39 | 2.41 | 2.59 |
| Mn .. .. .. | 0.66 | 0.66 | 0.68 | 0.67 |
| S .. .. .. | 0.097 | 0.097 | 0.096 | 0.099 |
| P .. .. .. | 0.17 | 0.17 | 0.17 | 0.15 |
| Tensile strength tons per sq. in. .. .. | 15.4 | 12.6 | 12.0 | 11.3 |
| B.H.N. .. .. | 180 | 171 | 167 | 170 |

As in the experiments described in the first report on small grids, the castings were run individually into the centre limb with a vertical runner situated

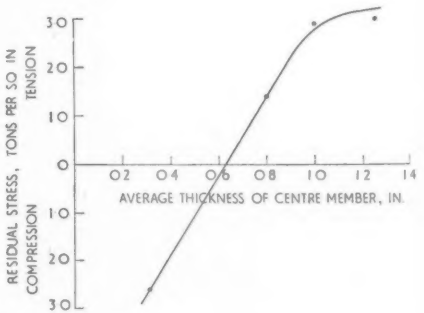



FIG. 4.—*Residual stresses in large-grid castings.*

some 3 in. from the end of the limb at the widest part of the grid. Three castings were made at each of the centre limb sections, two being intended solely for internal stress measurements and the third primarily for determination of the temperature differences, but was, in fact, also used to check the internal stress measurements. All determinations of

internal stress were carried out by electrical-resistance strain-gauges. Two gauges were attached to opposite faces of the centre member, to detect any bending which might have occurred on releasing the strain by cutting through the centre member.

Owing to the unfortunate failure of some of the couples during the casting operation, the temperature measurements were not as complete as was hoped, but they did suffice to determine the temperature differences existing in the castings with centre members of 1.0 and 0.3125 in. average thickness. The results of these temperature difference determinations are shown in Fig. 3. The irregularities in the curve at about 700 deg. C. are due to the transformations occurring in the iron during cooling at about this temperature. It will be noted that below 500 deg. C. the thin centre-member was cooling faster than the outer members. Unfortunately, the determinations were not continued in this case below 300 deg. C., but the form of the curve must be as that shown dotted.

All the castings remained in the mould until quite cold. On extraction, they appeared to be sound except that one of the castings with the smallest centre limb showed marked bending in that limb, suggesting that it was subject to compressive stresses. The results of the duplicate stress measurements of each of the castings are given in Table II. The

TABLE II.—*Residual Stress in Large-grid Castings.*

| Average thickness of centre member (in.). | Residual stress (tons per sq. in.) (duplicate measurements). | | | Average residual stress (tons per sq. in.) |
|---|---|---|---|---|
| 1.25 | 3.3<br>3.1 | 3.5<br>2.4 | 3.0<br>2.8 | 3.0 |
| 1.00 | 2.6<br>2.6 | 3.0<br>2.9 | 3.1<br>3.1 | 2.0 |
| 0.80 | 0.7<br>1.5 | 1.7<br>1.4 | 1.8<br>1.6 | 1.4 |
| 0.3125 | −2.5<br>−2.9 | −1.9<br>−3.1 | considerable bending | −2.6 |

*N.B.*—A negative sign indicates a compressive stress.

individual determinations are reasonably consistent and the averaged results are plotted in Fig. 4. It will be seen from Fig. 4 that the amount of tensile stress in the centre member increases with increasing thickness of centre member, *i.e.*, with increasing difference in temperature between the centre and outside limbs. It is particularly interesting to note that in the case of the thinnest centre limb, which cooled faster than the outside limbs, the residual stresses inverted and became compressive exactly as would have been predicted from theoretical considerations. The curve shows signs of bending over to the right to a horizontal position in the thickest centre members, but the course cannot be regarded as accurately determined since it is based on only two points. It is unfortunate that a casting with a still thicker centre member was not incorporated in the series as this would have permitted closer comparison with the corresponding experiments reported by Dodd.[3] Dodd found that the curve became horizontal when the cross-sectional area of the centre member was about 2.5 times the cross-sectional area of the outer limb. The ratio in the case of the thickest member of the present series was 1.6.

The residual stress should become zero when the cross-sectional area of the centre member is the same as that of the outer members which, with the present grid, occurs at a centre-member thickness of about 0.8 in. Actually the outer limbs behave as though they were of smaller cross-section because of their shape which gives them a larger surface: volume ratio. The position of neutral stress is, therefore, displaced to the left of the 0.8-in. thickness in Fig. 2 as would be expected.

These results completely confirm the work on the smaller grids and show that there is a clear relationship between the temperature differences existing within the casting and the residual stress. The figures do not reveal any marked scale effect since the stresses developed are about the same for a given temperature difference as they were in the

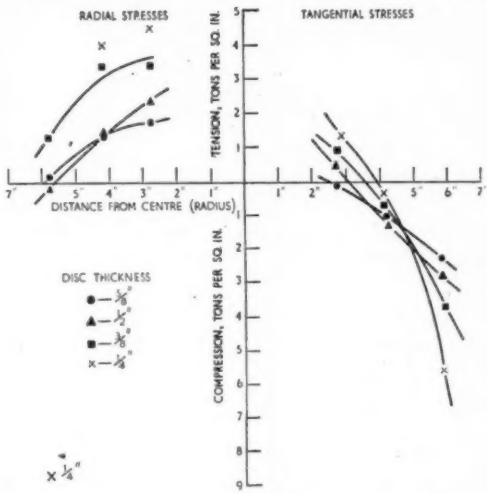



FIG. 5.—*Stress distribution in grey-iron discs.*

experiments of Parkins and Cowan[5] on smaller grids. Internal stresses may in fact vary in different sizes of casting of the same proportions because of changes in temperature differences.

## II. Tests on Cast Discs

Cracking troubles are frequently experienced in thin cast-discs, particularly if these are in a metal which does not readily undergo plastic deformation and if there be a heavy boss in the centre. It was, therefore, considered to be advisable to determine the stress distribution in cast discs under various conditions. A considerable number of preliminary measurements was made in discs of grey iron and of a 30 per cent. chromium iron. These discs were generally about 15-in. dia. with a thickness of ¼ to ⅜ in. with a centre boss about 3-in. in dia. and were poured through the centre boss. The thickness of the discs tapered from the boss to the periphery

to induce maximum temperature differences. Considerable difficulties were experienced in attaining reproducible results. These were partly due to bending of the discs and partly to imperfections on the casting surface and consequent irregular thicknesses. In general, the most that could be said was that there appeared to be tangential compressive-stresses near the periphery and radial tensile-stresses within the disc.

Following these preliminary results, which are not reported in detail, it was decided to make a further series of castings with flat parallel discs ranging in thickness from $\frac{1}{4}$ to $\frac{5}{8}$-in. in steps of $\frac{1}{8}$-in. All the discs were 13-in. dia. and had a central feeding-head about 3-in. dia. through which they

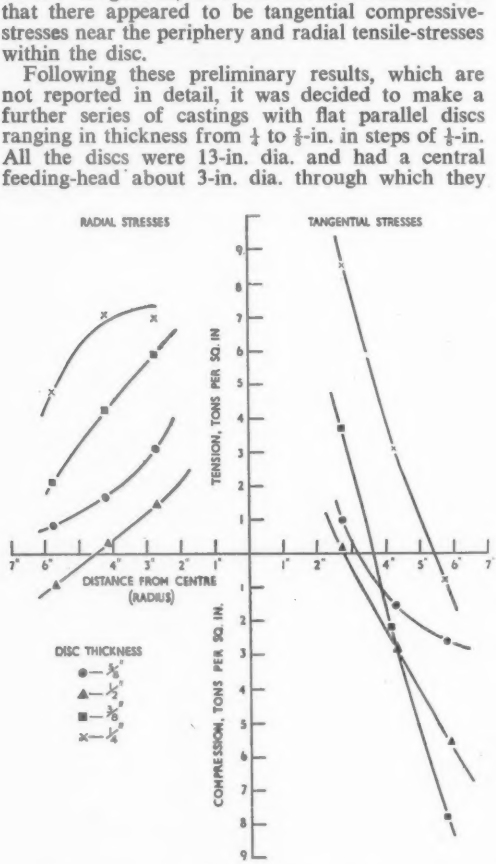



FIG. 6.—*Stress distribution in mild-steel discs.*

were cast (the heads of the grey-iron and mild-steel discs were 3½-in. dia. and of the austenitic steel were 2¾-in. dia.). This method of casting, although not the best way to achieve good casting surfaces, was retained in order to introduce the greatest and most uniform temperature difference between the centre and periphery of the discs. Discs were cast in grey cast-iron (T.C. 3.56; Si. 3.12; Mn. 0.95; and P. 0.93 per cent.), mild steel and austenitic steel of the type containing 23 per cent. chromium, 12 per cent. nickel, and 0.25 per cent. carbon. The mild-steel discs were prepared in triplicate at each size. In general, twelve resistance strain-gauges were used on each casting. Those for determination of the tangential stress were located on circles at a distance of 5¾, 4¼ and 2¾ in. respectively from the centre of the disc, three gauges being placed at each of the distances so that triplicate results were available for averaging. For the determinations of radial stress, one gauge was placed at each of the same three distances from the centre. The residual stresses were calculated assuming a two-dimensional stress system from

$$\sigma_x = \frac{E}{1-\mu^2}(e_x + \mu\, e_y)$$

where $\sigma_x$ is the stress in the x direction, $e_x$ and $e_y$ the measured strains in the x and y directions respectively, E Young's modulus and $\mu$ Poisson's ratio (=0.3 approximately).

To calculate the results, the strain readings from any one position were averaged and in the case of the mild-steel castings the results from the triplicate castings were also averaged. The results are plotted in Figs. 5, 6 and 7 for the grey-iron, mild-steel and austenitic-steel discs respectively. The stress distribution disclosed is regarded as generally correct but great accuracy is not claimed for the precise form of the curves, since each curve is based on only three points. Less reliance is placed on the results for the ¼-in. discs than for the others and in one case, the radial stress on the grey-iron ¼-in. disc, cannot be plotted because of very wide scatter of the points.

It is perhaps tempting to read more into the curves than is fully justified, but adopting a conservative interpretation, it is clear that discs in all the materials show comprehensive tangential-stresses at the periphery which become less on passing towards the centre of the disc, and in the region immediately around the central boss the tangential stresses become tensile. The radial stresses are generally tensile in character and increase in magnitude on passing from the periphery towards the centre of the discs.

This stress distribution is clearly due to the temperature gradients set up during cooling. The periphery of the disc solidifies first and cools most rapidly. In the early stages of cooling, it contracts and is able to compress and plastically deform the still soft, hot material around the centre of the disc. Later, this hot material itself cools and contracts. The contraction tends to pull into a smaller diameter the cold, stiff periphery of the disc, thus leading to compressive tangential stresses at the outside and to radial tensile stresses.

One might expect that the thinner discs would

TABLE III.—*Effect of Thickness of Mild-steel Discs on Reproducibility of Tangential Strain.*

| Thickness of disc (in.). | Distance of readings from disc centre (in.). | Individual strain readings. (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|---|
| 0.625 | 5.75 | −54 | −48 | −42 | −67 | −59 | −60 |
| 0.625 | 4.25 | −34 | −34 | −38 | −48 | −37 | −39 |
| 0.625 | 2.75 | +12 | −17 | −13 | −22 | −21 | −18 |
| 0.25 | 5.75 | −73 | −31 | −30 | −60 | −56 | — |
| 0.25 | 4.25 | − 3 | −20 | +37 | +20 | − 3 | — |
| 0.25 | 2.75 | +134 | +45 | +127 | +130 | +70 | — |

*N.B.*—A positive sign indicates a tensile strain and a negative sign a compressive strain.

show greater internal stresses because there should be greater temperature differences. The internal stresses measured in the mild-steel discs (Fig. 6) do tend to support this but the results on other materials can hardly be separated. As already pointed out, there is more variation in the results on the thin discs than on the thick discs, a fact which is illustrated by Table III which quotes the individual tangential-strain readings on several mild-steel castings of $\frac{5}{8}$-in. thickness and of $\frac{1}{4}$-in. thickness.

It is clear that there is much more variation in the readings quoted at any one distance from the centre on the $\frac{1}{4}$-in. discs than on the same distance from the centre of the $\frac{5}{8}$-in. discs. The lack of reproducibility in the determinations made on the

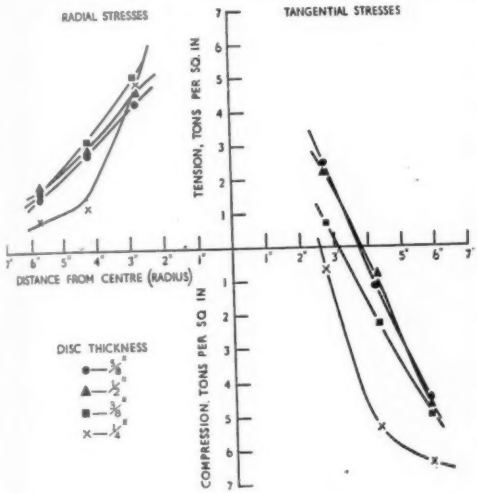



FIG. 7.—*Stress distribution in austenitic-steel discs.*

preliminary disc-castings is probably connected with the same fact since they were all $\frac{1}{4}$ to $\frac{5}{8}$-in. thick.

## CONSIDERATION OF RESULTS

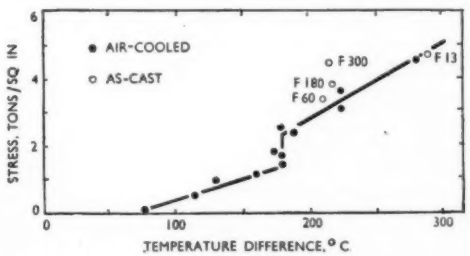
The work now reported confirms that described in the first report and that published by the other recent investigators quoted. The principal factor in determining the magnitude of residual internal stresses in castings is the temperature difference which arises within the casting during cooling. This applies to all materials, steels, cast irons and non-ferrous alloys, and all shapes of castings studied. If the temperature differences within the casting are decreased by such a procedure as casting into a warm mould, the internal stresses are correspondingly decreased. If the temperature differences within a casting are increased by altering the relative thicknesses of various parts of the casting, the stresses will correspondingly alter as was shown on the large-grid castings. It will be noted that tensile stresses are generally found in the heavier parts of the casting which are the last to cool. If a heavy part of a casting can be reduced in thickness so that it is lighter than the rest, the internal stresses will change from tensile to compressive.

For the same type of casting, the internal stresses appear to be related to the actual temperature differences which develop. There is insufficient evidence to show whether the stresses vary greatly in castings of widely-different size, but within the limits studied the differences do not appear to be great.

Treatment at sub-zero temperatures certainly does not reduce internal stresses but may easily increase them by setting up large temperature differences during cooling, at a time when the metal is so stiff that it cannot undergo plastic deformation to relieve the stresses.

The work in this Report does not include any further studies of the effect of the materials of which the mould is composed because this has been studied exhaustively by Parkins and Cowan[4, 5]. Their work may be summarized by stating that while changing the hardness of the sand mould will influence the amount of plastic strain undergone by a casting, residual stresses will generally result only if there are simultaneous differences in temperature. Similarly, the effect of phase transformations will generally be most marked by virtue of their influence on the temperature differences.

Fig. 8 taken from Parkins and Cowan[5] summarizes these findings very clearly. It shows that for grey cast-iron grids there is a fairly-close relationship between the temperature differences developed in a grid casting and the resulting internal stresses. The kink in the middle of the curve at a temperature difference of around 180 deg. C. is associated with the disturbance in temperature difference due to the phase transformation. The points on which this figure is based were obtained on grid castings which had been reheated and




[*Courtesy, Institute of Metals.*

FIG. 8.—*Relation between stress and temperature differences in small-grid castings.*

cooled in air under varying conditions to induce various temperature differences. Four further points appear on this illustration in the form of open circles. These were obtained on moulds of green sand (F.13) and of dry sand (F.60, F.180 and F.300) made with varying percentages of moisture and with varying additions of sawdust to produce final sands with compressive strength values corresponding to the figure given after the letter F. It is

interesting that the internal stress measured on the ordinary green sand, F.13, falls on the plotted straight line. The castings made in dry sands are displaced slightly from the straight line, the displacement increasing with increasing strength of sand. This figure thus gives a fair indication of the relative importance of the temperature effect and of the sand/strength effect.

It is interesting to add that similar determinations made on Y alloy did not show any displacement with increasing hardness of mould, all the points falling on one straight line. This is probably due to the fact that large variations in the strength properties of the dry sands develop only at relatively-high temperatures. Castings in aluminium alloys do not heat the sand sufficiently to raise it to the temperature which brings out the variations in strength, whereas cast iron is sufficiently hot to do so. The sand effect is thus shown by iron

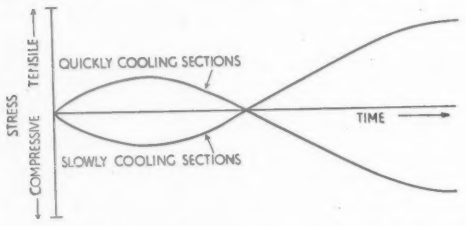



FIG. 9.—*Changes of stress in a casting during cooling.*

castings and not by aluminium-alloy castings under the conditions studied in this investigation. This is probably why Dodd[3] similarly failed to find any variation of internal stress with mould hardness.

### General Review of Phenomena During Cooling

Because of confusion between the different defects which can result from the contraction of castings in the mould, it may be useful to describe briefly the various processes. Metals at temperatures near their solidification points are often very weak and have a very low ductility. Because of this low ductility, they are unable to stretch as the cooling metal contracts around the mould material and the casting fails by *hot-tearing*. Hot-tears tend to appear in the hottest portion of the casting, *i.e.*, the portion which is of heaviest section and the last to solidify. Their tendency to appear is very much influenced by the presence of small quantities of low-melting-point eutectics which remain liquid around the growing crystals. When liquid films are present, the casting possesses practically no strength or ductility. Hot-tearing is thus influenced by the efficiency of feeding and hot-tears are very apt to appear in metal showing inter-crystalline unsoundness. The term hot-tears may be restricted to those cases in which some liquid, however small an amount, is present around the crystals. Failure occurs not because the stresses are high but because the metal cannot deform without the crystals parting along the lines of the liquid films.

As cooling proceeds below the dangerous region of hot-tearing, contraction correspondingly proceeds and the metal deforms plastically. It is important to note that at this stage internal stresses hardly exist because the metals are generally capable of yielding or undergoing creep to relieve the stresses, but as the temperature continues to drop, the mechanical properties of the metal increase and a balance is struck between the stress within the metal, the strain which it can undergo at that temperature and the stresses within the mould itself. Sometimes *hot-cracking* may occur, particularly as the metal becomes much stiffer on approaching closer to room temperature, but the location of the hot-cracks is usually different from that of hot-tears and the appearance of the fracture is different, lacking the roughness of the sides where dendrites have been torn apart which is characteristic of hot-tears.

*Distortion* may also develop during this stage and during final cooling to room temperature. This is closely associated with the building up of internal stresses due to temperature differences. Distortion occurs when the yield point or creep strength of the casting is below the stresses which have developed by temperature gradients. Finally, when room temperature is reached the casting is knocked out of the sand, the elastic stresses in the castings which are balanced by the sand disappear but those stresses which have resulted from the final cooling of one part of the casting being hindered by another rigid part which is already cold remain as internal stresses. Some of these stresses may be eliminated by distortion of the casting, but it would certainly not be safe to argue that a distorted casting is free from residual stresses, any more than it would be safe to argue that a straight casting is free. The one thing which does appear to be unchallengeable is that a casting of regular design, in which temperature differences do not develop, is much more likely to be free from internal stresses than a casting of complex design permitting the formation of large temperature-differences during cooling.

### Mechanism of Internal-stress Formation

It will be seen from the above description of the phenomena occurring during the cooling of a casting that those portions of the casting which at first cool more rapidly (*e.g.*, the lighter sections or the edges) tend to compress and to deform plastically the portions of the casting which cool more slowly (*i.e.*, the heavier sections). The stresses in the light sections in this early stage of cooling will generally be tensile and may lead to some stretching, whereas the stresses in the heavy sections are compressive and may be associated with plastic compression. As cooling proceeds, the light sections approach room temperature and become rigid, after which they can act as a stiffening skeleton, restraining the subsequent contraction of the hotter heavy sections. The stresses in the light sections, therefore, tend to become compressive and in the heavy sections to become tensile.

This sequence of stress changes may be shown, purely diagrammatically and not to scale, in Fig. 9.

which indicates how, with progressing time after the casting operation, the stresses in the quickly-cooling and slowly-cooling sections build up and then reverse. Only the stresses which are formed at relatively low temperatures remain as internal stresses.

This description of the development of internal stresses does not explain fully the significance of plastic deformation but plastic strain must be necessary because, if all the stresses and strains remained elastic from the completion of solidification down to room temperature, they would all become zero when the whole casting reached the uniform room temperature. In this case, the light, rapidly-cooling sections of the casting would first develop tensile stresses while the heavy, slowly-cooling portions would correspondingly develop compressive stresses; later in the process, when the heavy sections were cooling faster than the light sections, the compressive stresses would gradually decrease with a corresponding reduction in the tensile stresses in the light sections. Under these conditions of purely elastic stress, at room temperature all the stresses would be zero because all parts of the casting contract over the same temperature range.

These conditions do not arise in fact and under practical conditions plastic deformation takes place in the early stages of cooling and, given reasonable time at the higher temperatures concerned, the stresses are largely relieved by such deformation. In the case of the triangular-grid casting with the heavy centre-member, the outer members will elongate slightly under the tensile stress and the centre member will contract slightly under the compressive stress. Until the casting reaches a temperature at which its mechanical properties enable it to support a substantial elastic stress, no considerable internal stress can develop. As the temperature of the thinner outer limbs falls, so their rate of cooling slows down and at some point the rate of cooling of the hotter centre-limb begins to exceed that of the outer limbs. When the casting is below these two temperatures, tensile stresses begin to develop in the thicker centre-limb. The final magnitude of these stresses depends mainly on the temperature difference existing between the light and heavy sections at the moment when the stresses start to form. If there is a temperature difference of 200 deg. C., the centre member has to contract by an additional 200 deg. C. against the restraint of the colder and stiff outer members. The function of the plastic deformation at high temperatures is to enable the temperature differences to exist in a *stress-free* casting at the moment when tensile stresses start to form in the heavy section, so that the whole of the stresses subsequently developed remain as internal stresses. If the casting had been prestressed at the moment of initial formation of tensile stresses in the heavy section (*i.e.*, if there had been no plastic strain), the subsequently developed stresses would merely cancel the pre-existing stresses. The overall view is complicated by the fact that the mechanical properties of the metal do not change suddenly in the manner suggested. The change is gradual and is spread over a wide temperature range, but this does not alter the broad outline of the process.

The residual internal stresses are not normally obvious unless the casting distorts but an undistorted casting may in fact contain high internal stresses which may lead to actual fracture when some additional service stress is imposed or even when there are rapid changes in temperature, as may occur during storage in open air. They are also very apt to cause distortion during machining operations, when the removal of a stressed region leads to a consequential change of stress in the remaining part of the casting and so to distortion.

## RECOMMENDATIONS

The main conclusion from the work carried out by the sub-committee is that to avoid internal stresses by far the most effective method is to reduce the temperature differences which arise in the casting during cooling in the mould. The methods of doing this include changes in design by the padding or thickening of light sections and the thinning of heavy sections. The temperature distribution can also be altered by changes in the foundry technique. Casting into warm moulds, as applied in the lost wax method of making precision castings, is a good example. The use of chills or denseners adjacent to heavy sections will make them cool more rapidly. In exceptional cases, alterations in the conductivity of the sand in the mould can be applied to achieve the same effect. In very large castings, as has been demonstrated by Longden,[8] cooling air may be led by ducts to the heavy parts of the casting. In certain cases, it may be possible to retard the rate of cooling of the lighter sections by incorporating heaters in the mould or by casting extra masses of metal in the vicinity. Many of these methods are difficult of application in the foundry but are mentioned to illustrate the principles by which the problem may be tackled. Very often the most practical solution is to run the castings through the thinnest sections, so heating up the surrounding sand and retarding the cooling of the thin section.

### Acknowledgments

Many firms and other bodies have contributed to the large amount of work described in this Report. Castings have been made or other facilities provided by the British Cast Iron Research Association, Chamberlin & Hill, Limited, Ferranti, Limited, Jarrow Metal Industries, Limited, William Jessop & Sons, Limited, Sandholme Iron Company, Limited, and Sheepbridge Engineering, Limited. Practically the whole of the internal-stress measurements have been carried out in the Department of Metallurgy of the University of Durham at King's College, Newcastle-upon-Tyne. To all these bodies the sub-committee offer their most sincere thanks and warmest appreciation.

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# Meehanite Research Institute

*Conference at Scheveningen, Holland, June* 11-16

The 24th annual conference of the International Meehanite Research Institute was held at the Palace Hotel, Scheveningen, from June 11 to 16. It was of an international character, the hosts being the Meehanite licensees in Holland and the newly formed Meehanite Research Institute of the Netherlands who, together with Mr. P. Attenborough, of the parent organization, arranged the function. The hospitality shown to the visiting members was most cordial; members and their ladies were given an official reception by the municipal authorities in the "Rolzaal" at The Hague, at which addresses of welcome were given by Mr. H. Kurstjens, and the deputy-burgomaster, Mr. J. van Aartsen. Professor Dresden, president, National Council for Industrial Scientific Research of Holland, spoke on the subject of organized research, and Mr. E. M. Currie replied on behalf of the visitors. On Tuesday night, June 12, a reception was given to the members and ladies by the Government and Municipality at the Old Town Hall, The Hague.

**Technical Sessions**

Representatives at the conference included members from ten European countries, as well as some from America. The subjects discussed covered a wide range of ironfoundry activities, including many new and interesting developments. The conference opened under the chairmanship of Mr. E. M. Currie, managing director of International Meehanite Metal Company, Limited, who invited full discussion on the new ideas and methods which would be presented. At the opening session, the subjects discussed included "Improved Foundry Layout," presented with slides and a scale-model illustrating the principles of efficient layout and motion study; "Meehanite in Industry," in which a series of case-histories were given of applications of the metal in various industries; and a new wall chart of machining operations, incorporating essential facts and recommendations.

The second session was presided over by Mr. Oliver Smalley, president of the Meehanite Metal Corporation, at which papers were presented on the $CO_2$ Process; engineering and foundry design of castings; and the chemical cleaning of castings. The item on design included a sound film record of data on correct design principles, particularly planned for the information of engineers and designers. At the third session, the chair was taken by Dr. Ing. A. Palmucci, president of the Italian Meehanite Research Institute. The subjects discussed included "Cement/Sand Moulding in the Netherlands,"; "pH value as a Control Test for Moulding Sands"; "Foundry Reorganization and Mechanization"; "Core Assembly for Diesel-engine Castings," and "Defective Castings Control." The final session, presided over by Mr. J. C. Visser, of N.V. Machinefabriek en Ijzergieterij "Holland," was devoted to papers on moulding methods, and included "Casting Production Methods"; "Mould Production Units"; and "Production of Cores with Cold-setting Oils." Keen and prolonged discussion took place at all sessions.

Thursday and Friday, June 14 and 15, were spent on visits to the works of the Dutch licensees—Netherlands Dock & Shipbuilding Company, Wilton-Fijenoord N.V., Gebr. Stork & Company, N.V., Ijzer-en Metaalgieterij "De Globe," and Machinefabriek N.V. "Holland." The annual dinner for members and ladies was held in the Kurhaus Hotel, Scheveningen, on the evening of June 13, and was presided over by Mr. Bart Wilton, managing director of Wilton-Fijenoord N.V. The toast of the Research Institute was proposed by Mr. Visser and responded to by Mr. Oliver Smalley. Speeches of thanks to the Dutch hosts were made by Mr. W. R. Blakeborough, of England, Mr. J. Prado, of Spain, and Mr. G. Johnstone, of the United States. For the ladies, an extensive programme of visits was arranged during the period of the conference, including tours to places of interest at The Hague, Delft, Rotterdam and Amsterdam. The conference and visits concluded on Friday evening, June 15, with an outing to Laren near Hilversum, where ladies and gentlemen were entertained to dinner by the Meehanite Institute of Holland.

## London Aluminium Board

Mr. H. R. Cadman, who was not re-elected a director of the London Aluminium Company, Limited, at the annual meeting, was, the company states, re-elected to the board on a show of hands and had the complete confidence of the majority of the board, including the chairman.

Major C. R. Dibben, however, as chairman of the Midland Aluminium Company, Limited, which holds a 50 per cent. interest in the London Aluminium Company through the share option granted some years ago, demanded through that company's authorized representative at the annual meeting that a poll be taken, which went against Mr. Cadman.

A similar procedure was adopted by the chairman of the Midland Aluminium Company when Mr. J. E. O. Arnold's name was put forward for election in Mr. Cadman's place. Mr. Arnold's proposed appointment was turned down on a show of hands and it was not the wish of the majority of the board that he be elected. His election was only adopted on a poll with the use of the 50 per cent. shareholding.

## New Houldsworth School of Science

With the reorganization of three of its departments, Leeds University is commemorating the name of the late Sir Hubert Houldsworth in the establishment of the new Houldsworth School of Applied Science. Sir Hubert, who was chairman of the National Coal Board until his death on February 1, was formerly a lecturer in the Fuel Department at Leeds and later became Pro-Chancellor of the university.

The school will consist of the Department of Gas Engineering and General Fuel Science with Ceramics, directed by the Livsey Professor, Prof. A. L. Roberts; the Department of Chemical Engineering, to be directed by the Brotherton Professor, who is to be appointed shortly; and the Department of Metallurgy, directed by the Reader in Metallurgy, Dr. N. J. Petch. The work of the three departments within the school will be co-ordinated by a special committee.

### Indian Steel Mission Visit to London

An official Indian delegation, led by Mr. S. Bhoothalingam, secretary of the Indian Iron and Steel Ministry, left on June 24 for Europe to settle contracts for steel plants to be constructed in India. The delegation is first visiting Western Germany to conclude contracts with German businesses which will supply sections of steel plant and rolling mills at Rourkela, in Orissa. It will visit London later to settle the details of an agreement announced earlier this year with the Indian Steelworks Construction Company, Limited.

# New Patents

*(Copies of complete specifications are obtainable from the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, London, W.C.2, price 3s.)*

**749,007.** Walter Macfarlane & Company, Limited, 73, Hawthorn Street, Glasgow, N.

This patent refers to the production of grey cast-iron articles by the process claimed in the company's former patent **No. 660,677,** in which the dies are coated with a refractory dressing and thereafter coated with a film of lampblack or other insulating material. A cooling medium is applied to various parts of the dies to control the temperature of the working faces of the dies so that after each casting is made, no part of these faces will be at or above the critical temperature at which the lampblack when applied to the refractory dressing will burn away or cease to adhere, and no part of the die-faces will be cooled to such extent as will result in a white structure in the casting.

**749,029.** Stora Kopparberge Bergslags Aktiebolag, Falun, Sweden.

A blast-refined carbon-steel with a carbon content below 0.015 per cent., and preferably below 0.010 per cent. The content of manganese is below 0.25 per cent. and more than 1.7 times the percentage of sulphur.

**749,167.** Dow Chemical Company, Midland, Michigan, USA.

A magnesium-base alloy comprising thorium 0.5 to 8 per cent., manganese 0.2 to 2 per cent., the balance being magnesium.

**749,168.** Dow Chemical Company, Midland, Michigan, USA.

Magnesium-base alloy consisting of magnesium, having alloyed with it thorium 0.25 to 0.65, zinc 0.25 to 0.75, and zirconium 0.4 to 1 per cent. The zirconium dissolves in hydrochloric acid on subjecting a sample of the alloy to the action of 20 per cent. solution of aqueous hydrochloric acid.

**749,249.** Meigh Castings, Limited, Uckingham Foundry, Cheltenham, Glos.

A cast tool percussive bit. It is produced by casting non-ferrous metal or alloy around a steel core in a mould so that the steel core is enclosed and protected by the non-ferrous casting. The non-ferrous metal or alloy consists of aluminium-bronze (7 to 12 per cent. aluminium with the addition of other metals such as nickel, manganese or silicon). The alloy is stated to pass through a short phase during solidification in which the alloy is in a condition of "paste" or a condition in which there is no ductility—thereby avoiding shrinkage cracks in the cooling process.

**749,259.** Power Jets (Research and Development), Limited, 25, Green Street, London, W.1.

Blades, whether for use in elastic fluid turbines or in compressors, which are die-cast in metal (or moulded in plastic) to at least part of the desired profile of the blade, and comprising a stronger sheet-metal reinforcing member to which the cast metal (or plastic) is bonded.

**749,365.** Rolls-Royce, Limited, Nightingale Road, Derby.

A process for the production of a finished article (*e.g.*, blades for gas-turbine engines) from a titanium or titanium-base alloy blank by a hot-working operation.

# Parliamentary

## Technological Education

Proposing a motion welcoming the provisions of the Government's White Paper on technical education, but describing them as inadequate, MR. MICHAEL STEWART (Lab.) said that however many colleges of advanced technology were established they ought to be capable of doing the kind of work described in the Hives report. They should have a different status and dignity from that proposed in the White Paper. The diploma to be awarded ought not only to be the equivalent of a degree, it ought to be called a university degree.

SIR DAVID ECCLES, Minister of Education, moving an amendment welcoming the Government's proposals, said he intended to designate the Birmingham College of Technology, the Bradford Technical College, the Cardiff College of Technology and Commerce, the Loughborough College of Technology, the Royal Technical College, Salford, and in London the Battersea, the Chelsea, and the Northampton Polytechnics as colleges of advanced technology. These eight were provisional because he still had to satisfy himself that in so far as they did not already fulfil the necessary conditions, they would be able to do so in the near future.

He added that he did not like "Dip. Tech." It was a cacophonous abbreviation, and he had thought of offering a prize for a better name.

In the opinion of MR. ISAAC PITMAN (Con.) the real trouble the Minister was up against was the spiritual one that technical education was non-U whereas academic education was U. He was up against this problem in every official of his Ministry.

MR. JAMES CALLAGHAN (Lab.) said that compared with what other nations were doing and considering Britain's needs to-day, there could be no doubt that the programme fell short of what every independent critic and observer had kept saying about the situation.

MR. R. A. BUTLER, Lord Privy Seal, said that in spite of the pressure on our resources it was not the intention of the Government to economize on technical or higher technological education, but to go forward in a manner unprecedented by any Government since the war, or before. It would not be found that anything said by the Chancellor of the Exchequer subsequently would contradict this. The Government had decided to authorize further building to be started in 1957 at an estimated cost of nearly £4,500,000.

## Pig-iron and Scrap Prices

There was no necessary connection between the price of pig-iron and the prices of scrap iron and steel, which were not raw materials, said MR. RICHARD STOKES (Lab.), who asked the President of the Board of Trade what advice he had received from the scrap merchants before deciding on the recent increase of steel scrap from 151s. to 201s. per ton and cast iron from 118s. 9d. to 138s. per ton.

MR. A. R. W. LOW, Minister of State, Board of Trade, who replied, said that pig-iron and scrap were raw materials for the production of steel and of iron and steel castings, and they were substantially interchangeable. The Board of Trade did not consult scrap merchants before the decision was taken to increase the maximum prices of scrap. As required by Section 10 of the Iron and Steel Act, 1953, the Board of Trade consulted the Iron and Steel Board.

# Company News

BIRFIELD, LIMITED—As part of an internal reorganization of the group, Birfield Industries, Limited, has been formed with a capital of £100,000.

POWER SECURITIES CORPORATION, LIMITED—The one-for-four rights issue by the corporation forecast in May is to be made at a price of 28s. per share.

F. TURNBULL & COMPANY (ENGINEERS), LIMITED—A dividend of 10 per cent. is recommended for the year ended March 31, 1956, compared with 15 per cent. in the previous year. Profits amounted to £25,423, against £45,840.

PULSOMETER ENGINEERING COMPANY, LIMITED—Following application to the London Stock Exchange for permission to deal in and a quotation for the whole of the £560,000 ordinary capital in 5s. shares, dealings in the shares began last Thursday.

WAGON REPAIRS, LIMITED—Negotiations are expected soon for the take-over of the railway wagon works of Thomas Burnett & Company, Limited, Doncaster, by the company. Shareholders of Thomas Burnett are to hold a meeting to decide whether their shares should be sold.

W. H. BAXTER, LIMITED, quarry engineers and ironfounders, of Leeds—Net profits for the year to March 31, 1956, totalled £1,006, compared with £12,576 in the previous year. A dividend of 12½ per cent. is being paid, against 20 per cent. previously. The chairman states that the reduction in profits is due to rising costs. However, the company increased its prices at the end of the year, and faces the current year with "quiet but bold confidence."

RICHARDSONS, WESTGARTH & COMPANY, LIMITED—In his review of the year ended March 31, the chairman, Mr. O. J. Philipson, says that £285,000 was spent on plant and machinery and commitments at the year-end totalled £800,000. The board is considering further projects of a value of at least £1,000,000. Orders during the year were secured at a satisfactory rate and, with orders in hand in the region of £30,000,000, the board looks forward with confidence.

SPECIALLOID, LIMITED—From the issue of 1,099,926 ordinary 2s. shares at 3s. per share, 1,017,006 shares are required to satisfy the options exercised by the holders of the second debenture and preference shares, the rights exercised by the ordinary shareholders, and applications received from the staff. Applications for the remaining 82,920 shares total 166,867 shares. The basis of allotment will be as follows:—Up to and including 2,000 shares, in full; 2,001 to 5,000, 2,000; 5,001 to 6,000, 2,500; 6,001 to 7,000, 2,700.

JOHN THOMPSON, LIMITED, makers of boilers, superheaters, etc., of Wolverhampton—Group output increased by £5,871,615 in 1955 to a record of £23,217,099. Work in progress has advanced by £604,358 to £7,831,376. Mr. E. W. Thompson, the chairman, states that the year was one of development and further expansion. Considerable expenditure was incurred on development work, capital expenditure having increased by over £200,000 to £520,918, exclusive of £226,658 in respect of the South African subsidiary. Year-end commitments were £342,000.

BIRMINGHAM SMALL ARMS COMPANY, LIMITED—The company has cut its interim dividend from 4 to 3 per cent., less tax. Announcing this reduced interim payment for the year ending July 31 next, the directors state that trading results for the first nine months of the current financial year are lower than for the same period in the previous financial year. This is due partly to increased wage and other costs which have been absorbed, and to unfavourable trading in the motor and certain other sections, offset to some extent by satisfactory expansion in machine tools, steel, and heavy engineering, it is stated.

WHESSOE, LIMITED, makers of oil refinery plant, etc., of Darlington—Production of the company slightly exceeded the previous record in value in the year to March 31, 1956, but was restricted in volume owing to the shortage of steel. The chairman, Mr. C. M. Spielman, states that in this respect the future is not encouraging. The company had made plans for expansion to meet growing demand, but, he adds, there is "grave doubt if these plans will be supported by the necessary supply of steel, and of steel plate in particular." Orders received during the year and still to be executed, are a record.

# Contracts Open

*The dates given are the latest on which tenders will be accepted. The addresses are those from which forms of tender may be obtained. Details of tenders with the reference ESB can be obtained from the Board of Trade Export Services Branch, Lacon House, Theobalds Road, London, W.C.1 (telephone: CHAncery 4411, ext. 738 or 771), unless otherwise stated.*

INDIA, July 12—Railway track accessories, for the Director-General of Supplies and Disposals, Government of India. (ESB/16009/56.)

URUGUAY, August 1—Lead, copper, and bronze plates, bars, wires, and pipes, for the Administracion de Ferro-carriles del Estado. (ESB/15731/56.)

EGYPT, August 30—Overhead electric travelling crane, for the Egyptian Republic Railways. (ESB/15835/56.)

FORMOSA, July 23—Machine tools and hand tools, for the Central Trust of China, Purchasing Department, Taiwan. (ESB/16088/56.)

INDIA, October 1—Hydraulic hoists and controls for fixed wheel penstock emergency intake gates, for the Executive Engineer, Rihand Dam Construction Division No. II Mirzapur. (ESB/15841/56.)

INDONESIA, July 10—Machine tools, vehicles, cranes, office machinery, and electrical equipment, for the dockyard at Surabaya. (ESB/15623/56.)

PAKISTAN, August 15—Diesel shunting locomotives, for the Ministry of Communications (Railway Division), Government of Pakistan. (ESB/16178/56.)

SOUTH AFRICA, July 12—Planing and thicknessing machine, for the Union Tender and Supplies Board. (ESB/15990/56.)

SOUTH AFRICA, July 17—Abrasive cut-off machine, for the Stores Department of the South African Railways. (ESB/16304/56.)

# Board Changes

GASKELL & CHAMBERS, LIMITED—Mr. Martin M. C. Newey has been appointed a director.

PARMITER, HOPE & SUGDEN, LIMITED—Mr. Ralph H. Dean and Mr. William G. Corless have been co-opted to the board.

STERLING INDUSTRIES, LIMITED—Mr. J. W. Warrington has resigned from the board of the company and its subsidiaries.

BRITISH CHROME & CHEMICALS (HOLDINGS), LIMITED—Mr. H. C. Fairlie has resigned as a director of the company and of its subsidiaries.

# Recent Wills

WALKER, H. J., a director of Petford & O'Neill, Limited, brassfounders, of Birmingham ... ... £20,121

MILES, F. W., founder and managing director of Coventry Metallurgical Company, Limited ... £26,069

JONES, H. S., former chief engineer of Round Oak Steel Works, Limited, Brierley Hill (Staffs) ... £24,229

MACREADY, R. J., founder and chairman of Macready's Metal Company, Limited, iron and steel stockholders, of London, N.1 ... ... ... ... ... £96,909

MALLINSON, WILFRID, chairman of Henry Brook & Company, Limited, structural engineers, of Huddersfield, and former president of the West Riding of Yorkshire Ironfounders' Association ... ... £11,901

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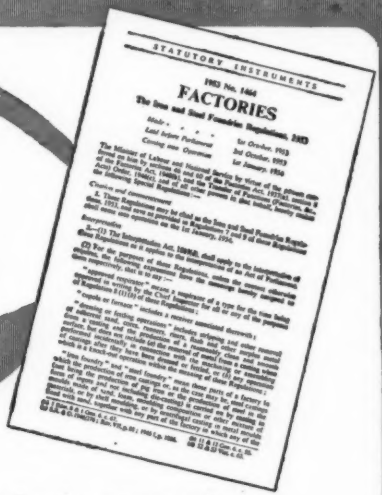
STATUTORY INSTRUMENTS

1953 No. 1464

FACTORIES

The Iron and Steel Foundries Regulations, 1953

Made . . . .

Laid before Parliament . . . 1st October, 1953

Coming into Operation . . . 1st October, 1953
1st January, 1954

The Iron and Steel Foundries Regulations 1953 say "Foundry gangways and Pouring Aisles shall have an even surface of hard material, and shall not have on them more sand than is necessary to avoid risk of flying metal from accidental spillage." The use of Refractory Concrete (made with Ciment Fondu and crushed firebricks or grog) will enable you to fulfil these conditions speedily, because Refractory Concrete . . .

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*AP3/130*

# Raw Material Markets

## Iron and Steel

With the holiday season approaching, during which most of the foundries will be closed for a fortnight, there will be some relaxation in the demand for raw materials, and due allowance is being made for this in the orders now being placed for pig-iron, etc. While the foundries are keen to obtain sufficient supplies of pig-iron for consumption needs and also for a working stock, most of them do not feel inclined to add appreciably to stocks in view of the present uncertain trend of business in many sections of the industry. This does not, of course, affect the demands for basic pig-iron from the steelworks, whose needs cannot be fully satisfied by home producers.

Supplies of hematite and low-phosphorus and medium-phosphorus iron for the engineering and speciality foundries have improved and are now nearer to fulfilling the needs of these foundries than has been the case for some time past. This results from the reduced demands from the motor vehicle and allied trades, and also from the additional source of supply which is now available. The demands for castings from the motor vehicle and tractor industry are steady and the foundries catering for them are obtaining fairly good outputs, but are not under heavy pressure as before. Other engineering foundries supplying castings to makers of machine tools, power plant and electrical equipment, and agricultural implements, and to steelworks, collieries, etc., are very busy. They are now able to obtain larger supplies of pig-iron in the grades most suitable for their use. In addition, some of the furnaces producing low-phosphorus iron are able to spare some tonnages for fresh users.

The supply of high-phosphorus pig-iron from the reduced number of furnaces now producing this grade is about sufficient for the needs of the foundries. There is, however, little to spare, although present demands from the foundries are not on a large scale. The jobbing foundries are fairly well occupied, but the light and textile foundries are quietly placed. The domestic utensil trade is quiet and the building trade is not taking up the amount of castings which it normally does at this period of the year.

The scrap position is satisfactory, while foundry coke is coming forward in sufficient quantities for requirements. Ganister, limestone, and firebricks are in good supply.

The re-rollers continue to be very busy; most of them have order-books sufficient to keep them fully employed for some months ahead. Orders on hand are mainly for home consumers and stockists, who continue to specify freely. Some business is on hand for oversea buyers, but this is small compared with the amount for which inquiries are being received. Deliveries of steel semis are maintained at recent levels, and, with the supplies from both home steelworks and shipments from oversea, the re-rollers are fairly well off for steel. Pressure continues to be heaviest for the smaller sized billets and for carbon and alloy steels. All suitable arisings of slightly defective billets and crops are readily accepted.

## Non-ferrous Metals

Markets have weakened considerably in London under the influence of a number of factors. The Rhodesian Selection Trust group has once more reduced its fixed copper price to United Kingdom consumers, a large tonnage of copper is to be sold from the UK strategic stockpile, and the steel strike in the United States has made its mark on the tin, lead, and zinc markets. Furthermore, dealings are now under the shadow of the holiday season.

Copper in the UK has been particularly vulnerable. The new RST fixed price of £275 a ton came into effect on Monday with a drop of £25 a ton from the previous quotation and when it was made known that the Board of Trade was proposing to sell up to 36,000 tons of copper in the current financial year, the London copper price sank on Monday to £264 a ton. Discussions will be held with trade representatives to ascertain how the disposals may be best arranged to avoid market disturbance. No sales will be made before the middle of next month.

The US primary producers' price of 46 cents a pound is out of all proportion and even if it were lowered to 40 cents, to bring it into line with the Custom smelters' quotation, it would be equivalent to £320 a ton. The only bullish point for an early rise in the copper price are the rumblings of labour trouble from Chile and the Rhodesian Copperbelt, but these have not yet achieved serious proportions.

Lead and zinc have been very much under the shadow of the US steel strike. Demand for "Prime Western" zinc in the States has slowed as orders from galvanizers, who would have to shut down if the strike were prolonged, slumped. Demand for high-grade metal has not been good because of the fall in automobile production and it is believed that buying is on a very small scale now as diecasters are fairly well stocked.

Demand for lead is also quiet, with the price gradually easing and both lead and zinc prices are now definitely dependent on US stockpiling.

The international tin agreement came into effect at the beginning of this week. The first meeting on Monday was a formal affair and the International Tin Council—the governing body of the pact—is not expected to become a market factor for some time as a good deal of groundwork has still to be done. M. Georges Peter, of France, has been elected chairman of the council. Meanwhile, the tin market is quietly steady, with dealers more active than consumers.

Official metal prices were as follow:—

COPPER, Standard—*Cash:* June 28, £283 to £285; June 29, £274 to £275; July 2, £265 to £266; July 3, £262 to £264; July 4, £277 to £278.

*Three Months:* June 28, £287 10s. to £288; June 29, £277 to £278; July 2, £269 to £271; July 3, £266 to £267; July 4, £277 10s. to £278.

TIN, Standard—*Cash:* June 28, £742 to £744; June 29, £739 to £741; July 2, £735 to £736; July 3, £730 to £731; July 4, £738 to £738 10s.

*Three Months:* June 28, £738 to £739; June 29, £735 to £736; July 2, £729 to £730; July 3, £725 10s. to £726; July 4, £732 10s. to £733.

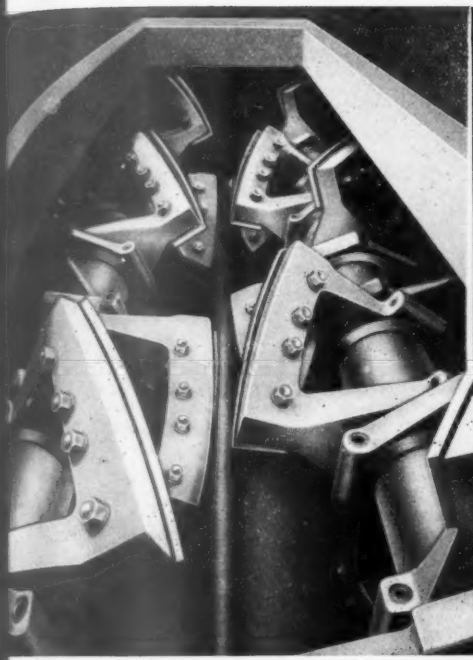
LEAD—*Second half June:* June 28, £112 5s. to £112 10s.; June 29, £111 10s. to £112. *First half July:* July 2, £111 to £111 10s.; July 3, £110 10s. to £111; July 4, £112 10s. to £112 15s.

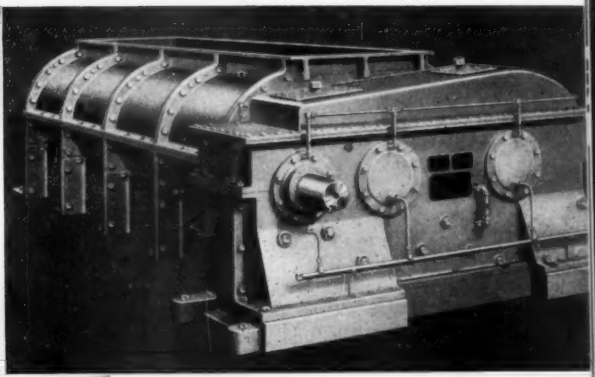
*Second half September:* June 28, £110 5s. to £110 10s.; June 29, £109 5s. to £109 10s. *First half October:* July 2, £109 to £109 5s.; July 3, £109 to £109 5s.; July 4, £110 10s. to £111.

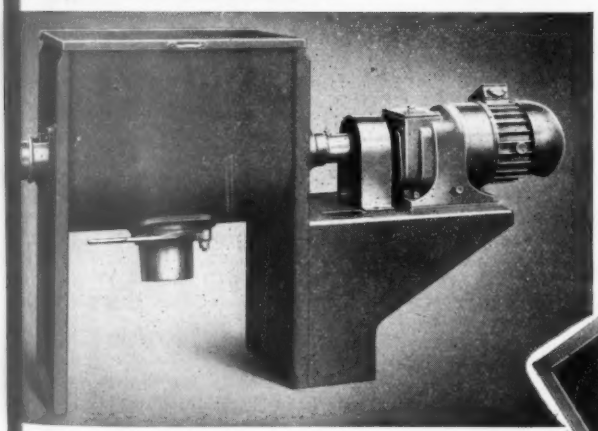
ZINC—*Second half June:* June 28, £92 to £92 5s.; June 29, £92 to £92 10s. *First half July:* July 2, £92 5s. to £92 10s.; July 3, £91 15s. to £92; July 4, £92 5s. to £92 15s.

*Second half September:* June 28, £90 15s. to £91; June 29, £91 to £91 5s. *First half October:* July 2, £90 15s. to £91 5s.; July 3, £90 10s. to £90 15s.; July 4, £91 5s. to £91 10s.

# Batch and Continuous Sand Mixers

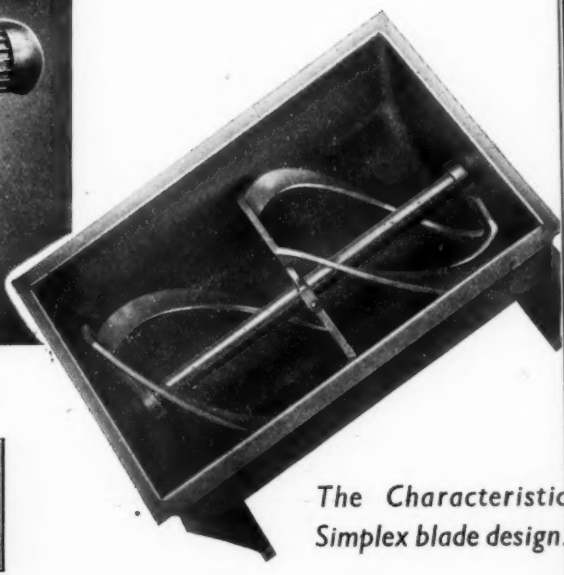






## CONTINUOUS MIXER

**As made and installed by Bake Perkins, U.S.A. in America' largest foundries.**
**Built in standard sizes wit continuous outputs of 6 tons t 120 tons per hour of thoroughl aerated and homogeneously mixe moulding sand.**



CH MIXERS Made in a variety of sizes.

*The Characteristic Simplex blade design.*

BAKER PERKINS LTD
*Engineers*
STWOOD WORKS – PETERBOROUGH

# Current Prices of Iron, Steel, and Non-ferrous Metals

*(Delivered unless otherwise stated)*

**July 4, 1956**

## PIG-IRON

**Foundry Iron.**—No. 3 IRON, CLASS 2:—Middlesbrough, £17 11s. 0d.; Birmingham, £17 3s. 3d.

**Low-phosphorus Iron.**—Over 0.10 to 0.75 per cent. P, £20 8s. 0d., delivered Birmingham. Staffordshire blast-furnace low-phosphorus foundry iron (0.10 to 0.50 per cent. P, up to 3 per cent. Si), d/d within 60 miles of Stafford, £20 12s. 3d.

**Scotch Iron.**—No. 3 foundry, £21 14s. 6d., d/d Grangemouth.

**Cylinder and Refined Irons.**—North Zone, £23 16s. 6d.; South Zone, £23 19s. 0d.

**Refined Malleable.**—P, 0.10 per cent. max.—North Zone, £25 4s. 0d.; South Zone, £25 6s. 6d.

**Hematite.**—Si up to 2 per cent., S. & P. over 0.03 to 0.05 per cent. :—N.-E. of England (local iron), £21 7s. 6d.; Scotland (Scotch iron), Zone S. 1, £21 14s. 0d.; Sheffield, £22 14s. 6d.; Birmingham, £23 2s. 0d.; Wales (Welsh iron), £21 7s. 6d.

**Basic Pig-iron.**—£18 3s. 0d. all districts.

## FERRO-ALLOYS

*(Per ton unless otherwise stated, delivered)*

**Ferro-silicon** (6-ton lots and over).—45 per cent. Si, £48 0s. 0d. to £50 5s. 0d., scale 16s. 0d. to 17s. 6d. per unit; 75 per cent. Si, £70 0s. 0d. to £73 2s. 6d., scale 16s. 0d. to 17s. 6d. per unit.

**Ferro-vanadium.**—50/60 per cent., 27s. 6d. per lb. of V.

**Ferro-molybdenum.**—65/75 per cent., carbon-free, 11s. 6d. per lb. of Mo.

**Ferro-titanium.**—20/25 per cent., carbon-free, £250 0s. 0d.; 38/40 per cent., £299 0s. 0d.

**Ferro-tungsten.**—80/85 per cent., 17s. 10d. per lb. of W.

**Tungsten Metal Powder.**—98/99 per cent., 20s. 10d. per lb. of W.

**Ferro-chrome** (6-10 ton lots).—4/6 per cent.C, £93 10s.0d. to £95 0s. 0d., basis 60 per cent. Cr, scale 29s. 9d. to 32s. 0d. per unit; over 6 per cent. C, £92 10s. 0d. to £93 0s. 0d., basis 60 per cent. Cr, scale 29s. 9d. to 32s. 0d. per unit; 2 per cent. C,* 2s. 1d. per lb. Cr; 1 per cent. C,* 2s. 1½d. per lb. Cr; 0.15 per cent. C,* 2s. 2½d. per lb. Cr; 0.10 per cent. C,* 2s. 2¾d. per lb. Cr; 0.06 per cent. C,* 2s. 3d. per lb. Cr.

**Metallic Chromium.**—98/99 per cent., 7s. 0d. to 7s. 6d. per lb.

**Metallic Manganese.**—93/95 per cent., carbon-free, £249 0s. 0d.; 96/98 per cent., £259 0s. 0d. to £265 0s. 0d.

**Ferro-columbium.**—65/72 per cent., Nb + Ta, 22s. 6d. to 23s. 6d. per lb., Nb + Ta.

**Ferro-manganese** (home).—78 per cent., £66 0s. 0d.

## SEMI-FINISHED STEEL

**Re-rolling Billets, Blooms, and Slabs.**—BASIC: Soft, u.t., £28 19s. 0d.; tested, 0.08 to 0.25 per cent. C, £29 19s. 0d.; hard (0.41 to 0.60 per cent. C), £31 0s. 6d.; silico-manganese, £39 10s. 0d.; free-cutting, £33 3s. 0d. SIEMENS MARTIN ACID: Up to 0.25 per cent. C, £36 14s. 6d., silico-manganese, £39 17s. 6d.

**Billets, Blooms, and Slabs for Forging and Stamping.**—Basic, soft, up to 0.25 per cent. C, £34 13s. 6d.; basic, hard, over 0.41 up to 0.60 per cent., C, £35 16s. 0d.; acid, up to 0.25 per cent. C, £38 17s. 6d.

## FINISHED STEEL

**Heavy Plates and Sections.**—Ship plates (N.-E. Coast), £35 7s. 0d.; boiler plates (N.-E. Coast), £37 17s. 0d.; floor plates (N.-E. Coast), £36 16s. 0d.; sectional material, N.-E. Coast, £33 16s. 6d.

**Small Bars, Sheets, etc.**—Rounds and squares, under 3 in., untested (4-ton lots), £36 3s. 0d.; flats, 5 in. wide and under (4-ton lots), £36 3s. 0d.; hoop and strip, £36 12s. 6d.; uncoated strip mill coils, hot rolled, under 3mm. to 12g., £38 16s. 0d.; black sheets (hand mill), 17/20 g., £50 4s. 6d.; galvanized corrugated sheets, 24 g., £62 9s. 0d.

**Alloy Steel Bars.**—1 in. dia. and up: Nickel, £61 13s. 9d.; nickel-chrome, £85 10s. 6d.; nickel-chrome-molybdenum, £96 16s. 6d.

## NON-FERROUS METALS

**Copper.**—Cash, £277 0s. 0d. to £278 0s. 0d.; three months, £277 10s. 0d. to £278 0s. 0d.; settlement, £278 0s. 0d.

**Copper Tubes, etc.**—Solid-drawn tubes, 2s. 8½d. per lb.; rods, 298s. 6d. per cwt. basis; 20 s.w.g., 331s. 9d. per cwt.

**Tin.**—Cash, £738 0s. 0d. to £738 10s. 0d.; three months, £732 10s. 0d. to £733 0s. 0d.; settlement, £738 10s. 0d.

**Lead (Refined Pig).**—First half July, £112 10s. 0d. to £112 15s. 0d.; first half October, £110 10s. 0d. to £111 0s. 0d.

**Zinc.**—First half July, £92 5s. 0d. to £92 15s. 0d.; first half October, £91 5s. 0d. to £91 10s. 0d.

**Zinc Sheets, etc.**—Sheets, 15 g. and thicker, all English destinations, £123 15s. 0d.; rolled zinc (boiler plates), all English destinations, £121 10s. 0d.; zinc oxide (Red Seal), d/d buyers' premises, £110.

**Brass Tubes, etc.**—Solid-drawn tubes, 2s. 4½d. per lb.; rods, drawn, 3s. 0½d.; sheets to 10 w.g., 293s. 0d. per cwt.; wire, 2s. 10d.; rolled metal, 293s. 0d. per cwt.

**Brass (Brazing).**—BS1400, B3 (65/35), £178; B6 (85/15), —; BS249, —.

**Brass (High Tensile).**—BS1400, HTB1 (30 tons), £232; HTB2 (38 tons), —; HTB3 (48 tons), £255.

**Gunmetal.**—BS1400, LG2 (85/5/5/5), £252; LG3 (86/7/5/2), £262; G1 (88/10/2/½), —; (88/10/2/1), £295.

**Phosphor Bronze.**—BS1400, PB1 (AID released), £340 per ton.

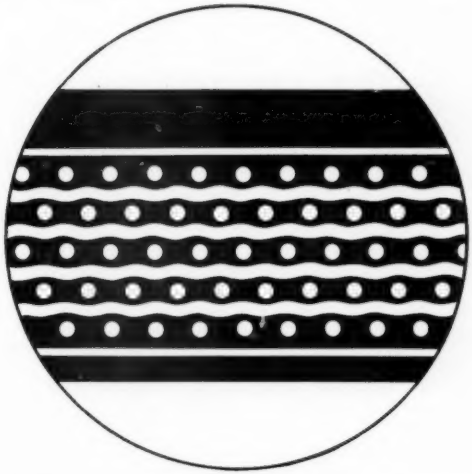
**Phosphor Bronze Strip, etc.**—Strip, 401s. 3d. per cwt.; sheets to 10 w.g., 425s. 9d. per cwt.; wire, 4s. 2¾d. per lb.; rods, 3s. 6½d.; tubes, 3s. 4¾d.; chill cast bars: solids 3s. 6½d., cored, 3s. 7¾d. (CHARLES CLIFFORD, LIMITED).

**Nickel Silver, etc.**—Rolled metal, 3 in. to 9 in. wide × 0.056, 3s. 11½d. per lb.; round wire, 10g. in coils (10 per cent.), 4s. 4d.; special quality turning rod, 10 per cent., ½ in. dia., in straight lengths, 4s. 3d. All prices are net.

**Other Metals.**—Magnesium, ingots, 2s. 4d. per lb. Antimony, English, 99 per cent., £210 0s. 0d. Quicksilver, ex-warehouse, £86 0s. 0d. Nickel, £519 0s. 0d. Aluminium ingots, £189 0s. 0d.; aluminium bronze (BS1400), AB1, —; AB2, —. Solder, brazing, BS1945; type 8 (50/50), 3s. 1d. per lb., type 9 (54/46), 3s. 4½d. per lb.

* Average 68-70 per cent.

# Focus on conveyor belting proves Goodyear superiority



There is obviously only one way of proving to yourself beyond any doubt that Goodyear conveyor belting gives long and reliable service. That's by installing it.

But for proof in advance there's the record of efficiency of Goodyear conveyor belts in thousands of existing installations in this country—in steelworks, power stations, mines, quarries, factories and foundries.

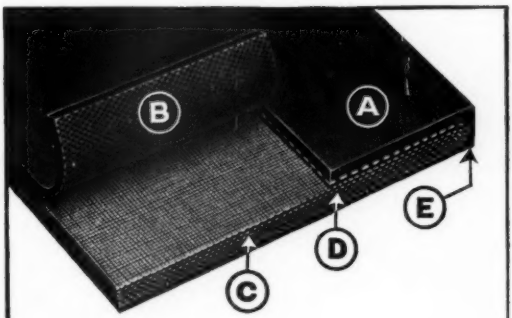
At a big steelworks, for instance, Goodyear belts conveying hot sinter are lasting over twice as long as other makes previously used.

## QUICK PROOF

Focus on conveyor belting proves Goodyear superiority, and quickly confirms that Goodyear belting makes every conveying job an economic proposition.

The emphasis is on *every*. Whatever the conveying work, there's a "job-designed" Goodyear belt to do it at the lowest cost per ton.

This cost-saving is ensured by the exceptionally high quality built into every Goodyear belt. And this quality is ensured by rigid adherence to raw material specifications and stage by stage production inspection.




**RUGGED CONSTRUCTION OF GOODYEAR BELTING**

**A** Tough, heavy-duty cover compounded to suit job.
**B** Breaker fabric to improve bond between cover and carcass—when required.
**C** Plies of close-woven duck, inhibited against mildew.
**D** Skim coat between plies prevents separation.
**E** Rugged edge cover resists wear.

## QUICK DELIVERY

You can now get quick delivery of Goodyear conveyor belts, which are available with cotton or rayon carcass in any width up to 72 inches. They can be supplied in a few weeks against specific ordering.

**GOODYEAR** INDUSTRIAL RUBBER PRODUCTS

CONVEYOR BELTING · TRANSMISSION BELTING · V-BELTS · INDUSTRIAL HOSE

# News in Brief

THE ADDRESS of Birfield, Limited, is now Stratford House, Stratford Place, London, W.1 (telephone: GROSVENOR 7090).

THE British Thomson-Houston Company, Limited, Rugby, has offered £25,000 towards the cost of residential accommodation at the new Rugby College of Technology.

MR. L. L. BOYD, managing director of the Indian branch of the United Steel Companies, Limited has secured a contract, valued at £487,500, for 5,000 wheel sets for the Indian Railways.

A CONTRACT worth about £130,000 has been placed with Dorman Long (Bridge & Engineering), Limited, by the Eastern Region of British Railways for the new railway bridge between Sandy (Beds) and Blunham on the Bedford-Cambridge line.

ROWLEY REGIS BOROUGH COUNCIL decided on June 25, to set up a special committee to investigate complaints arising from a petition received from residents near the works of Dudley and Dowell, Limited, whose foundry at Gradley Heath was alleged to be causing a nuisance.

AT Qualcast, Limited, Derby, 350 foundrymen were placed on a four-day week as from July 2. It was stated that the step was taken with the full knowledge and agreement of the employees' representatives and was due to a reduction in orders from motor customers of the firm.

PERMISSION has been given for the erection of a £5,000,000 synthetic-rubber plant at Fawley, Southampton, by the International Synthetic Rubber Company, Limited. It is estimated that in about two years the plant will be producing 50,000 tons of synthetic rubber a year, a saving of 30,000,000 dollars.

THE WORLD BANK has approved a loan of $75,000,000 (£26,900,000) in various currencies to the Tata Iron & Steel Company of India, to assist in the financing of a large-scale expansion programme to raise the company's annual output to 1,500,000 long tons of finished steel (2,000,000 long tons of ingot steel).

CHARLES CARR, LIMITED, Grove Lane, Smethwick, 40, Birmingham, announce that they have opened a London office at 19, Great Winchester Street, London, E.C.3 (telephone nos. LONDON Wall 6714/6715) and that inquiries will be dealt with either by head office or by the London representative, Mr. F. A. Blake.

A CONTRACT for the supply and erection of five water turbines and their alternators for India to a total value of some £1,250,000 has been awarded to the English Electric Company, Limited. Each developing 77,000 h.p., the sets are for a new power station on the Rihand River in the State of Uttar Pradesh.

THE INDIAN GOVERNMENT purchased stores worth some £11,500,000 in Britain during the financial year 1955-56. The purchases, made through the India Store Department of the High Commission of India, set an all-time record, and were higher than purchases from any other country in Europe during the period.

BECAUSE of the acute shortage of nickel for civilian use in the United States, the Bureau of Foreign Commerce of the Commerce Department has banned exports of nickel scrap in the third quarter. The restriction also applies to exports of remelt nickel-bearing alloy ingots and other forms of secondary nickel-bearing scrap.

THE FIRST STAGE of a £650,000 rolling mill development plan, involving the installation of three new rolling mills for the increased production of high-carbon precision cold-roller strip, will be completed this month at the Stocksbridge works of Samuel Fox & Company, Limited, a subsidiary of the United Steel Companies, Limited.

APPROVAL has been given by Hartlepool Corporation to proposed extensions, costing £2,000,000, to the works of the Steetley Magnesite Company, Limited. A condition that a new rotary kiln was not to be put into operation until a dust nuisance from the works had been abated has been withdrawn following a visit to the works by corporation representatives.

AMERICAN PRESIDENT of the Caterpillar Tractor Company, Mr. Harmon S. Eberhard, in Glasgow to check up on the progress of his new factory at Tannochside, Lanarkshire, went to the site and asked to be allowed to try out one of the huge earth-moving tractors. The driver came down and looked on sceptically as Mr. Eberhard took over his seat. "I suppose," quizzed Mr. James Munro, the company's Scottish chief, "he knows how to handle it?" But Mr. Eberhard was just the man who designed it!

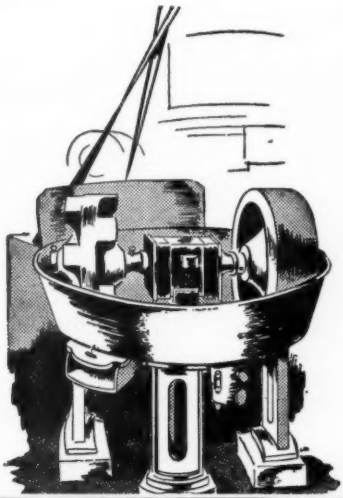
THE INDUSTRIAL WELFARE SOCIETY is using the title "Approach to Industrial Responsibilty" for the seventh annual conferences for apprentices, to be held at Keble College, Oxford. The first is to take place from September 4 to 8, and 8 to 12. It is also organizing two residential courses for overseas executives on "Human Relations and Managerial Responsibility," which are to be held at Christ's College, Cambridge, from July 1 to 13 and July 15 to 27. Details are available from the society at Robert Hyde House, 48, Bryanston Square, London, W.1.

STERLING METALS, LIMITED, Coventry, one of the Birmid Industries, Limited, group, has dismissed 46 foundry labourers because of the recession in the car industry. Notices expired on June 29. The men dismissed were chosen on the "last in first out" principle, in consultation with shop stewards. The firm makes cylinder-blocks and -heads, some of which are used by the Standard Motor Company. The position at Standard's has affected Sterling Metals, it is stated, but the redundancy was due to a recession in the trade generally. There was every prospect that the men would get back their jobs when the position in the industry improved.

A CLAIM for damages for personal injuries against a local firm was heard at Sheffield Assizes on June 25. R. B. Walker, aged 55, of Fitzwilliam Street, Hoyland Common, near Barnsley, had his right arm trapped between a conveyor belt and a roller at the works on January 19, 1954. Mr. R. Withers Payne said that Walker was cleaning out a tunnel below the foundry floor at the works when he slipped and fell. His right hand and arm were trapped. Mr. Payne said, "At the time of the accident, guards had been removed and had not been replaced." It was said that he was virtually now a one-armed man, and Dr. Philip Lewis said Walker had suffered delusions and hallucinations since the accident and had been in a mental hospital for three months. But his outlook for the future was reasonably good, said Dr. Vincent G. Crotty, psychiatrist. Mr. Justice McNair said Walker was "a poor risk in the labour market," though the firm had promised to find him a suitable light job. He awarded £5,580 damages to Walker, £250 of the claim to be paid forthwith, and a stay of 21 days was granted on the balance, pending appeal.

# 'FULBOND'

## works perfectly in a simple mill like this...



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**THE FULLERS' EARTH UNION LTD.**

Patteson Court, Redhill, Surrey. Tel: Redhill 3521. CHF. 16

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## REPEATEDLY PROVEN INGOTS

IN

BRASS

MANGANESE BRONZE

GUNMETAL PHOSPHOR BRONZE

AND LEAD BRONZE

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Powell Duffryn House
Adelaide Street
Swansea
Tel. Swansea 4035

## Personal

Mr. FRANK GODFREY, works' manager, at Taylor's Bell Foundry, Loughborough, has returned after a two month's business trip to America.

Nottingham University is to confer the honorary degree of Master of Arts on Mr. E. G. PHILLIPS, the chairman of its Engineering Advisory Committee.

Among the new members of the Council of the Institute of Directors is Lord CLITHEROE, whose business appointments include a directorship of Borax Consolidated, Limited.

Nomination as the next president of the National Smoke Abatement Society has been accepted by Dr. R. LESSING. He will succeed Sir ERNEST SMITH, whose term of office expires in October.

Mr. JOHN WILLIAM HUNTER, of Monsanto Chemicals, Limited, Newport, was elected chairman of the Cardiff and District Industrial Safety Committee of the Royal Society for the Prevention of Accidents in Cardiff on June 25.

Mr. JOHN S. V. ANDREWS has been appointed chief planning engineer at the Sunderland headquarters of James A. Jobling & Company, Limited, manufacturers of Pyrex brand scientific, laboratory, and glass apparatus.

To hold meetings on technical matters with members of the Railway Board staff, Mr. C. F. RYAN, chief of the railways material department of Steel, Peech & Tozer, a branch of the United Steel Companies, Limited, is to visit India.

Because of his duties as president of the Iron and Steel Institute, Dr. H. H. BURTON, a director of the English Steel Corporation, Limited, Sheffield, is handing over full charge of the corporation's research department to Mr. T. R. MIDDLETON, chief metallurgist and a special director.

In order to reduce his business activities, Mr. G. R. T. TAYLOR has retired from the chairmanship and the board of Pinchin, Johnson & Associates, Limited, paint manufacturers, etc., of London, E.14. He is also chairman of International Combustion (Holdings), Limited, and International Combustion, Limited.

According to Mr. R. A. SIMPSON, who has been in Australia studying market requirements, he is leaving for this country shortly and will return to Australia later as general manager and director of two factories which the David Brown organization is to establish with the ultimate aim of manufacturing tractors in the Commonwealth.

MR. GEORGE D'ARCY NASH has been elected president of the Australian (Victoria) branch of the Institute of British Foundrymen. During the war he served with the Royal Australian and Mechanical Engineering Corps, attaining the rank of Major. After the war he resumed his industrial career with Morgan Crucible (Australia) Pty., Limited. He is now the manager of the Victoria branch of that company.

A newcomer to the English Electric Company, Limited, group is Sir ARCHIBALD HOPE, who has been appointed a director of D. Napier & Son, Limited, the aero and marine engineering concern. Sir Archibald has resigned his directorship of Airwork, Limited, the independent air transport operating company, and intends to resign also from the post of chairman of the British Independent Air Transport Association.

Following the acquisition of the control of the Scottish Motor Traction Company, Limited, by Sears Holdings, Limited, the latter's chairman, Mr. CHARLES CLORE, has joined the SMT board. Other new directors are Mr. L. SAINER and Mr. J. C. GARDINER, who both hold board appointments within the Sears group, and Lord ELGIN, chairman of the Fairfield Shipbuilding & Engineering Company, Limited. Of the former SMT directors only Sir ANDREW MURRAY remains on the reconstituted board.

Mr. J. G. ALLEN, general manager and director of Head Wrightson Steel Foundries, Limited, has been honoured by being appointed a Serving Brother of the Noble Order of St. John of Jerusalem. Mr. Allen joined the St. John Ambulance Brigade (Stockton and Thornaby division) in 1919, and acted for 21 years as secretary and treasurer, when he became hon. treasurer, which position he still holds. Four years ago he was made president of the Stockton and Thornaby division. Now in this 36th year as treasurer he still maintains the Brigade as his chief interest in spite of the many other associations which take up so much of his time. Mr. Allen is a member of the Tees-side branch of the Institute of British Foundrymen, secretary of the North East Association of Steel Founders, chairman of the Main Casting Committee of the BSFA and a member of the British Standards Institution—steel castings specifications committee.

Vickers Limited, Broadway, Westminster, London, S.W.1, announce the following changes in organization, effective from July 1: Mr. A. H. HIRD, A.C.G.I., B.SC., M.I.MECH.E., is appointed a special director of Vickers, Limited, and adviser on group commercial engineering sales. He also takes over the chairmanship of A.B.C. Motors, Limited, Cooke, Troughton & Simms, Limited, and Ioco Limited. Mr. Hird remains on the board of Vickers-Armstrongs, Limited, as engineering sales director, and on the board of Vickers-Armstrongs (Engineers) Limited. Mr. E. J. WADDINGTON, A.C.A., and Mr. R. P. H. YAPP relinquish their seats on the boards of Ioco Limited and Cooke, Troughton & Simms, Limited, respectively, and Mr. Waddington relinquishes the chair of A.B.C. Motors Limited, but remains on the board of that company. Mr. R. WONFOR is appointed to the board of Vickers-Armstrongs (Engineers) Limited as sales director. Mr. J. E. RICHARDSON, O.B.E., is appointed a director of Vickers-Armstrongs (Engineers) Limited, retaining his existing office of deputy general manager and engineering manager, Barrow works. Rear-Admiral Sir ANTHONY BUZZARD, Bart., C.D., D.S.O., O.B.E., is appointed a special director of Vickers-Armstrongs, Limited, and assistant to the managing director.

## Obituary

Mr. ARTHUR JOSEPH MATTHEWS, who died on June 26, was managing director of Matthews Bros., Limited, iron, steel, etc., stockbrokers, of London, W.C.2.

The death has taken place of Mr. FRANK MARRIOTT, M.B.E., manager of the Stockton section of Head Wrightson Steel Foundries, Limited. Mr. Marriott was a member of the Tees-side branch of the Institute of British Foundrymen and had been 30 years with the company. He was awarded the M.B.E. in 1955 for services to the industry.

The death has occurred of Mr. JAMES SPENCER HOLLINGS, C.B.E., at the age of 86. After leaving Sedburgh, he was trained as a mining engineer, but in 1893, joined the Brymbo Steel Company, Limited, and was the first man to work the basic open-hearth process in this country. For this pioneer work and other services to the industry he was awarded the Bessemer Gold Medal in 1946.

## Publications Received

**Mechanical Handling Equipment in British Transport.** Published by the British Transport Commission, 222, Marylebone Road, London, N.W.1.

This is an excellent review covering most forms of mechanical equipment used by the railways, road services and canals. It is well laid-out and nicely illustrated.

**"Why Not Work Study?"** (Action pamphlet 7). Published by the British Productivity Council, 21, Tothill Street, London, S.W.1; price 9d. net.

A prominent industrialist once wrote that work-study can be a great boon, but unless properly handled it can be a dangerous explosive. He insisted that its inception should be sponsored by what he called a "top-drawer" executive. If this be borne in mind, then this simplified version of what to do is excellent, as it outlines a commonsense approach to the subject.

**National Foundry Craft Training Centre.** Issued by the Management Committee, and obtainable from the secretaries, Heathcote and Coleman, 69, Harborne Road, Birmingham, 15.

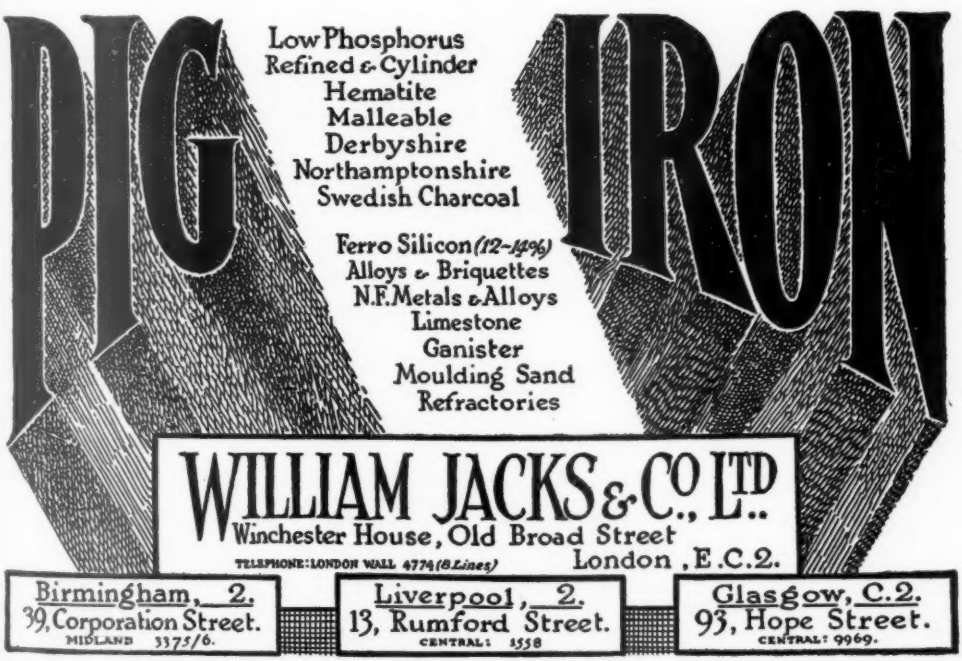
In attractive form, at long last, there now appears a 12-page, well-illustrated booklet, which assembles all the details which a foundry executive should know before sending his lads to the National Foundry Craft Training Centre. Costs and details of the courses are clearly set out. Every foundry owner throughout the country should see that he is in possession of this pamphlet. It will either reinforce his impressions of the work done, or draw his attention to an excellent service organized by the industry for the industry.

## New Catalogues

**Ultrasonic Flaw-detector.** A new brochure issued by Solus-Schall, Limited, 15-18, Clipstone Street, Great Portland Street, London, W.1, gives an excellent description of an ultrasonic flaw-detector, designed by Dr. J. Krautkramer, and augments this by illustrating a number of special applications. Readers may obtain copies by writing to Clipstone Street.

**Fine and Precision Assemblies,** Mark Perks, Limited, 41 to 42, Tenby Street North, Birmingham, 1, have submitted an interesting catalogue. The word interesting is used because of the wide range of components it covers within the limits of eight pages. The firm has presses up to 30 tons capacity; does enamel work; makes jewellery and turns out precision castings of beryllium/copper and aluminium alloys. It also makes jewellers' "findings"—a new word in the reviewer's vocabulary. In short in this catalogue one finds a number of articles, the makers of which, in the ordinary way, are difficult to locate. The catalogue is available to readers on writing to Birmingham.

**Hydraulic Cleaning of Castings.** Ernest Fairbairn, Limited, Manfield House, 376, Strand, London, W.C.2, have submitted a German catalogue from their principals, Graue G.m.b.H, of Hanover, covering a system of cleaning castings using either high- or medium-pressure water. The catalogue takes the form of a six-page folder and, included on page four, are two line drawings of plants—one having hydraulic control of movement of the jet and the second hand control in addition to a sand-reclamation system. The nature of the savings expected to accrue from installation of the plant are set out. The catalogue is available to readers on writing to Manfield House.



# CLASSIFIED ADVERTISEMENTS

**PREPAID RATES:** Fifteen words for 7/6 (minimum charge) and 4d. per word thereafter. Box Numbers 2/6 extra (including postage of replies.) Situations Wanted 2d. per word.

**Advertisements (accompanied by a remittance) and replies to Box Numbers should be addressed to the Advertisement Manager, Foundry Trade Journal, John Adam House, 17/19, John Adam Street, Adelphi, London, W.C.2. If received by first post Monday advertisements can normally be accommodated in the following Thursday's issue.**

## SITUATIONS WANTED

EXPERIENCED FOUNDRY SUPERVISOR seeks position with progressive Iron Foundry. Would introduce up to 2 tons jobbing castings per week. 60 miles radius London. Box EF184, FOUNDRY TRADE JOURNAL.

FOUNDRY MANAGER/TECHNICIAN. Iron and Non-Ferrous. 18 years' managerial experience. — Box FM200, FOUNDRY TRADE JOURNAL.

CORESHOP FOREMAN (44), 28 years in iron and steel foundry, desires change. Experienced in all classes of modern mechanised foundry practice. Used to trainees, 15 years' supervision.—Box CF198, FOUNDRY TRADE JOURNAL.

## SITUATIONS VACANT

FOUNDRY TECHNICAL CONTROL.—An opportunity exists with a progressive company for a young man to be taught foundry technical control. The position would give valuable practical experience to a graduate wishing to specialise in foundry work; or to a laboratory assistant wishing to extend his knowledge of foundry practice. Applicants who desire further information should state their age, and give particulars of education, or present and past employment, and say if they have fulfilled their National Service obligations.—Box FT172, FOUNDRY TRADE JOURNAL.

FOUNDRY Plant Manufacturers in the Birmingham area require SENIOR DRAUGHTSMAN, with mechanical handling and/or structural experience, for highly mechanised cupola melting plants.—Full details to PERSONNEL MANAGER, Incandescent Heat Co., Ltd., Cornwall Road, Smethwick.

OPPORTUNITY exists for a capable, young and energetic METALLURGIST, to set up a laboratory and establish technical control in an iron foundry producing castings for rolling stock. Previous experience of melting in the cupola is necessary and experience of electric melting desirable. The laboratory to be set up would eventually serve the whole of the manufacturing establishment. Replies, which will be treated in confidence should be addressed to the MANAGING DIRECTOR, Charles Roberts & Co., Ltd., Horbury Junction, Wakefield.

DRAUGHTSMAN (aged 25 or over) required for general Foundry Engineering and Maintenance work. Salary commensurate with qualifications and experience. Contributory superannuation scheme. Chesterfield district.—Write, giving full particulars, to Box DA180, FOUNDRY TRADE JOURNAL.

LONG ESTABLISHED firm of Die-Casters requires SALESMAN to sell Zinc Base Alloy Pressure Die-Castings, and Aluminium Alloy Gravity Die-Castings, on a straight commission basis. Please state fully, details of other lines carried, area at present covered, and commission required. Box LE177, FOUNDRY TRADE JOURNAL.

## SITUATIONS VACANT—*contd.*

METALLURGIST required for Iron Foundry, South-East England. Experience of melting, sand control, and mechanised production preferred. Pension Fund and Employees' Share Holding Scheme operated.—Write, stating age, experience, and salary required, to Box MR166, FOUNDRY TRADE JOURNAL.

FOUNDRY FOREMAN, experienced executive for Roll Foundry and other castings.—State experience, qualifications, and wages required, Box FF974, FOUNDRY TRADE JOURNAL.

ASSISTANT TO SALES MANAGER required by William Cook & Sons (Sheffield), Ltd. Applicants should be between the ages of 25-35 years, and Technical education or Steel Foundry experience is essential as duties will comprise the estimating of weights from drawings, pricing of castings, etc. The position would be partly inside and partly outside. Replies, giving details of experience, salary expected, etc., will be treated in the strictest confidence.

PRACTICAL FURNACE MAN required to supervise smelting and refining operations. Applicants must be thoroughly conversant with oil and gas fire furnaces and should have good knowledge of fuel efficiency methods. Good salary and bonuses for right man according to ability. Five-day week. Company's Pension and Insurance Scheme available. Apply in the first instance in writing, in confidence, to MITCHAM SMELTERS, LTD., Red House Road, Mitcham Road, Croydon.

CHARGEHAND IRON MOULDER for London district. There are good prospects for a practical man, for whom accommodation can be provided. Apply Box CM188, FOUNDRY TRADE JOURNAL.

FOREMAN PATTERNMAKER required for Semi Mech. Foundry producing 100 tons per week High Duty Iron by machine and Sand Slinger. Reply stating full details of training and experience, together with salary required to FOUNDRY MANAGER, Sykes & Harrison, Ltd., Bangor, North Wales.

METALLURGIST required to supervise operation of new Indian Steel Foundry with 2-tons capacity Side Blown Steel Converters, etc. For particulars apply GEORGE GREEN & Co., Foundry Equipment Engineers, Keighley, Yorks.

A DIRECTORSHIP would be considered for an experienced man to take charge of production in a new company being formed for the manufacture of Rainwater and Soil Castings. Premises and Plant available. Box AD189, FOUNDRY TRADE JOURNAL.

ASSISTANT METALLURGIST for Malleable Iron Foundry in Midlands. Experience of modern melting practice and sand control essential. Applications in writing, stating age, qualifications and salary required to Box AM193, FOUNDRY TRADE JOURNAL.

## SITUATIONS VACANT—*contd.*

### FOUNDRY METALLURGIST.

LARGE Engineering Company in the East Midlands desires to engage a young energetic man with experience of cupola control and sand control. Knowledge of non-ferrous melting desirable. Must be capable of displaying initiative and have an interest in development work. Excellent welfare and sports facilities. House available. Write stating age, qualifications, experience and salary desired to Box FM190, FOUNDRY TRADE JOURNAL.

MECHANICAL AND STRUCTURAL DESIGN DRAUGHTSMAN for Foundry Engineer's Department for development project work. Pension scheme. Write in confidence to the STAFFING OFFICER, The Stanton Ironworks Co., Ltd., near Nottingham.

YOUNG METALLURGIST required for an old established but progressive non-ferrous foundry in Melbourne, Australia. Experienced in shell moulding and shell casting an advantage. Applicants should send details of their careers with copies only of testimonials and use air mail paper, to Box 2999, FOUNDRY TRADE JOURNAL.

ESTIMATOR required with experience in foundry and pattern making practice. Applications in writing to give age, experience and present salary to G. D. PETERS & Co., LTD., Windsor Works, Slough, Bucks.

TOOLROOM FOREMAN. Wanted immediately for Die Shop covering gravity and pressure dies for Aluminium Alloy castings. Permanent position for suitable applicant. Please reply stating experience and salary required, etc., to: WORKS MANAGER, William Mills, Ltd., Friar Park Road, Wednesbury, Staffs.

ALUMINIUM PRESSURE DIE FOREMAN. Wanted immediately to control all Production Casting, Fettling Shop and Maintenance of Dies. Permanent position for suitable applicant.—Apply, stating experience and salary required, to: WORKS MANAGER, William Mills, Ltd., Friar Park Road, Wednesbury, Staffs.

### FOUNDRY METALLURGIST.

A VACANCY exists for a light alloy foundry metallurgist in a modern foundry in Eastern Ontario. The following are essential qualifications which the applicant must possess: A degree or its equivalent, a minimum of five years experience in metallurgical control in a light alloy foundry, preferably one handling both magnesium and aluminium, a sound knowledge of metal melting and alloying, sand control, heat treatment and radiography, and an active interest in the technicalities of production of Class I castings for aircraft. Housing accommodation can be made available for a suitable applicant. All applications should be made by air mail, giving full details of past experience and qualifications together with a recent photograph of the applicant addressed to the MANAGER, Light Alloys Limited, Haley, Ontario, Canada.